TISA (Time-Space Averaging) Update

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SSAI

14th CERES-II Science Team Meeting
Earth Radiation Budget Workshop 2010
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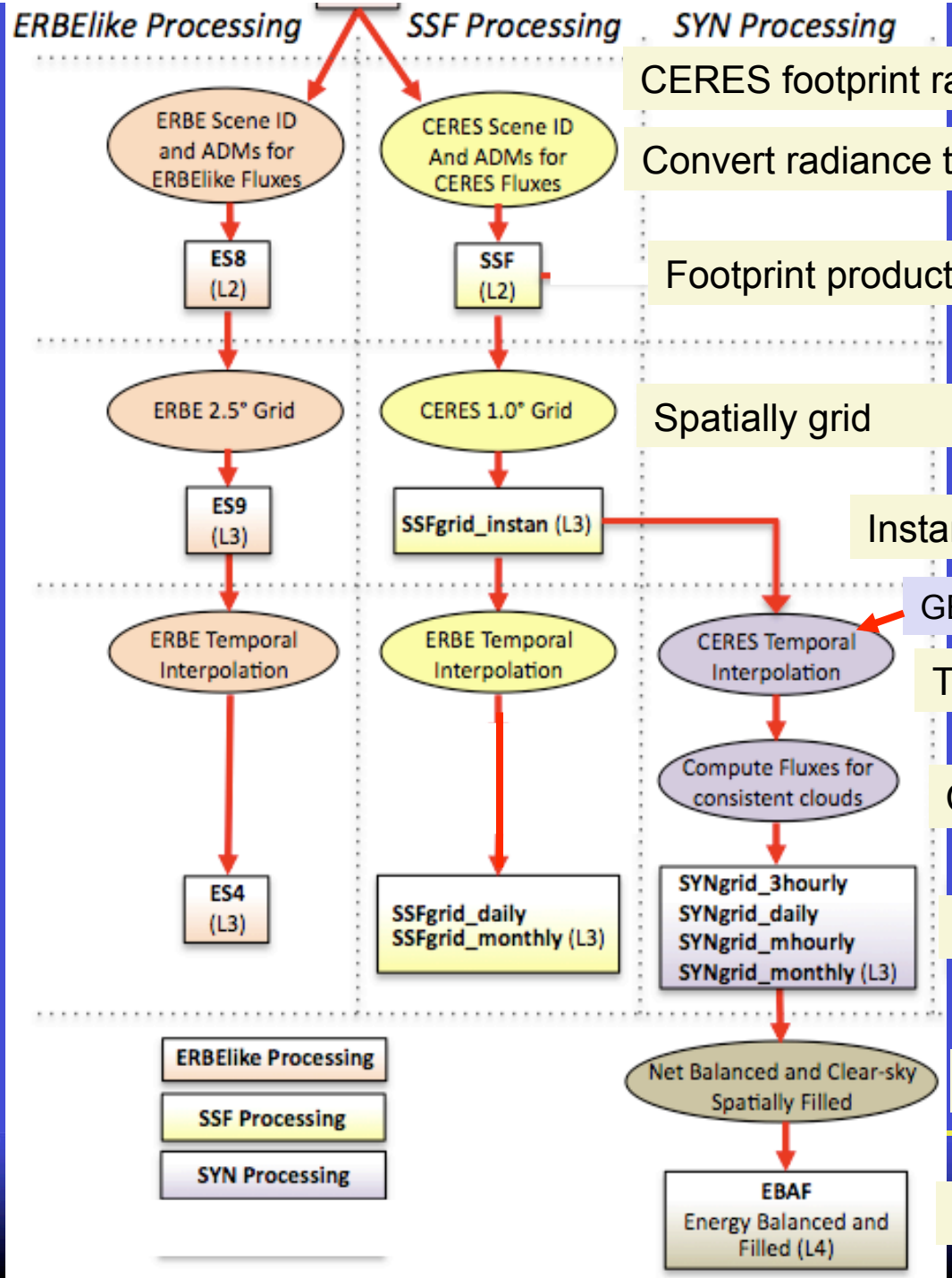
Outline

- Overview of CERES product streams
  - Flux differences between streams highlighted
- Edition 2.5 processing status
  - Processing flowchart and data inputs
- GEO calibration update
  - GEO calibration against MODIS
  - GEO stability monitoring with desert
- CERES prototype ordering tool improvements
  - Availability and ordering statistics
  - Integration of Edition2 into pages
  - Improved plotting capabilities

CERES Product flowchart



CERES footprint radiances

Convert radiance to flux

Footprint products

Spatially grid

Instantaneous gridded products

GEO enhanced diurnal interpolation

Temporal Interpolation

Computed fluxes

Level 3 products

Net balance fluxes

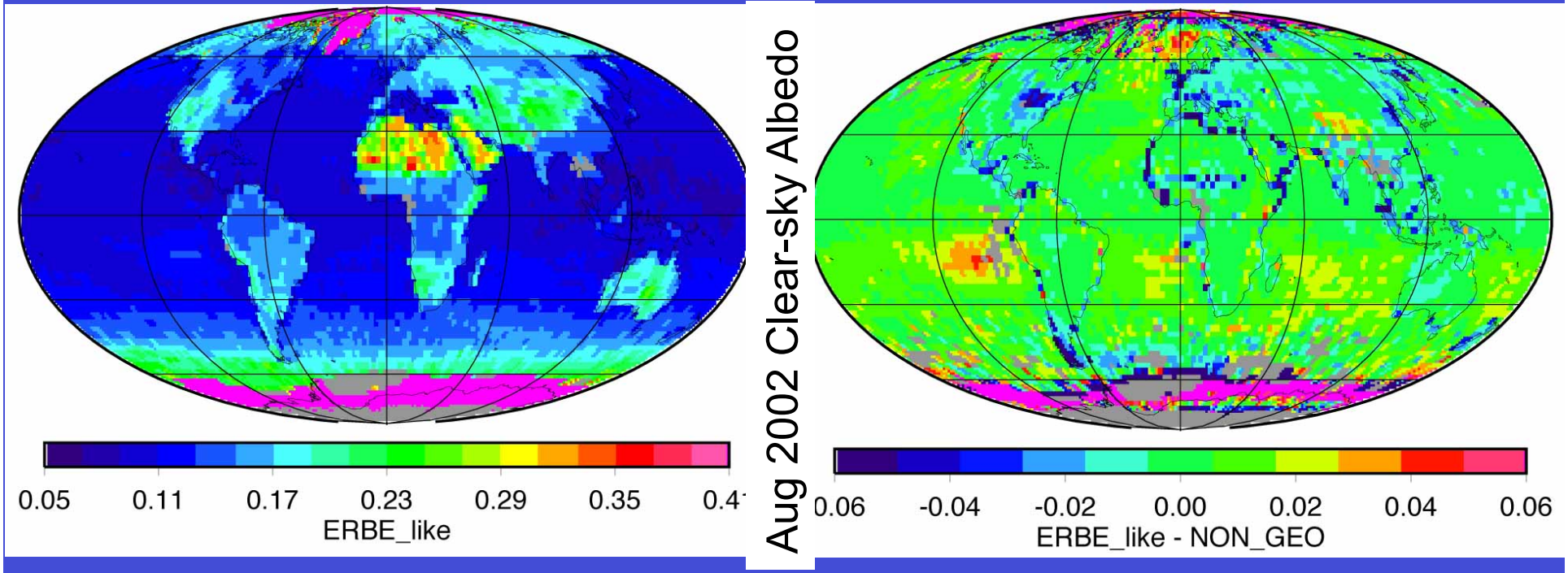
Level 4 products

ences

CERES ADM improvements

ERBE like mean

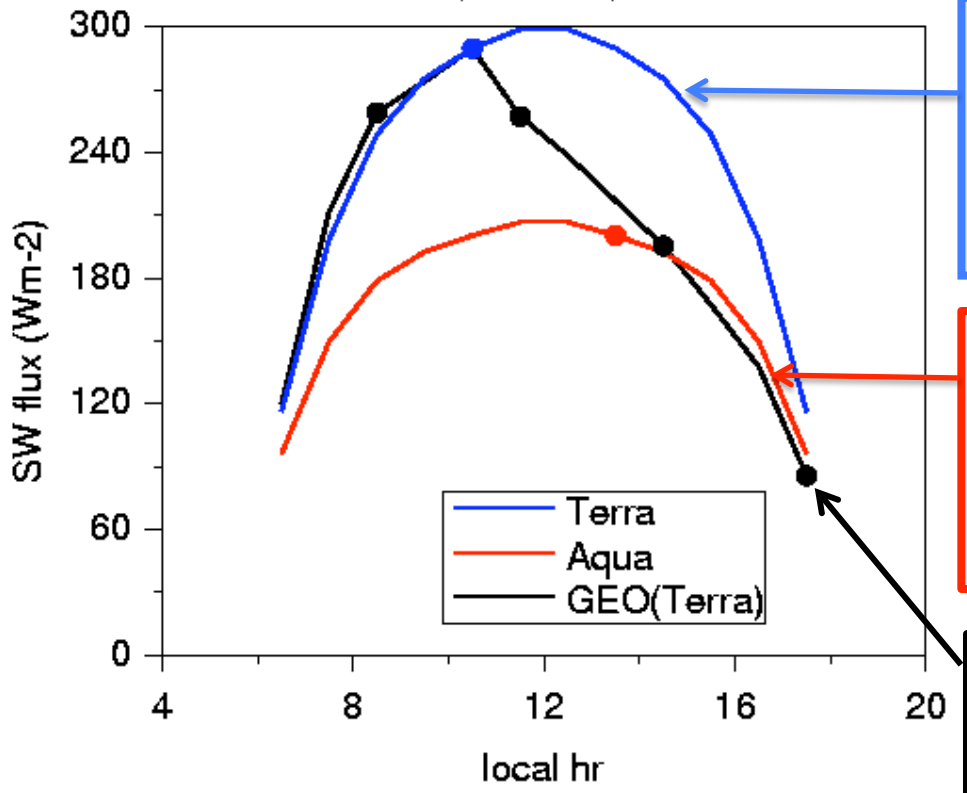
ERBE like - nonGEO



- The CERES ADMs and scene identification is an improvement over ERBE-like
  - especially clear-sky scene identification, and polar cloud retrievals
- CERES ADMs show no dependencies with cloud properties or regionally

The merged CERES/GEO SW diurnal flux

• Peruvian maritime stratus region example, morning stratus clouds that burn off in the afternoon, expect greater SW flux in the morning than afternoon



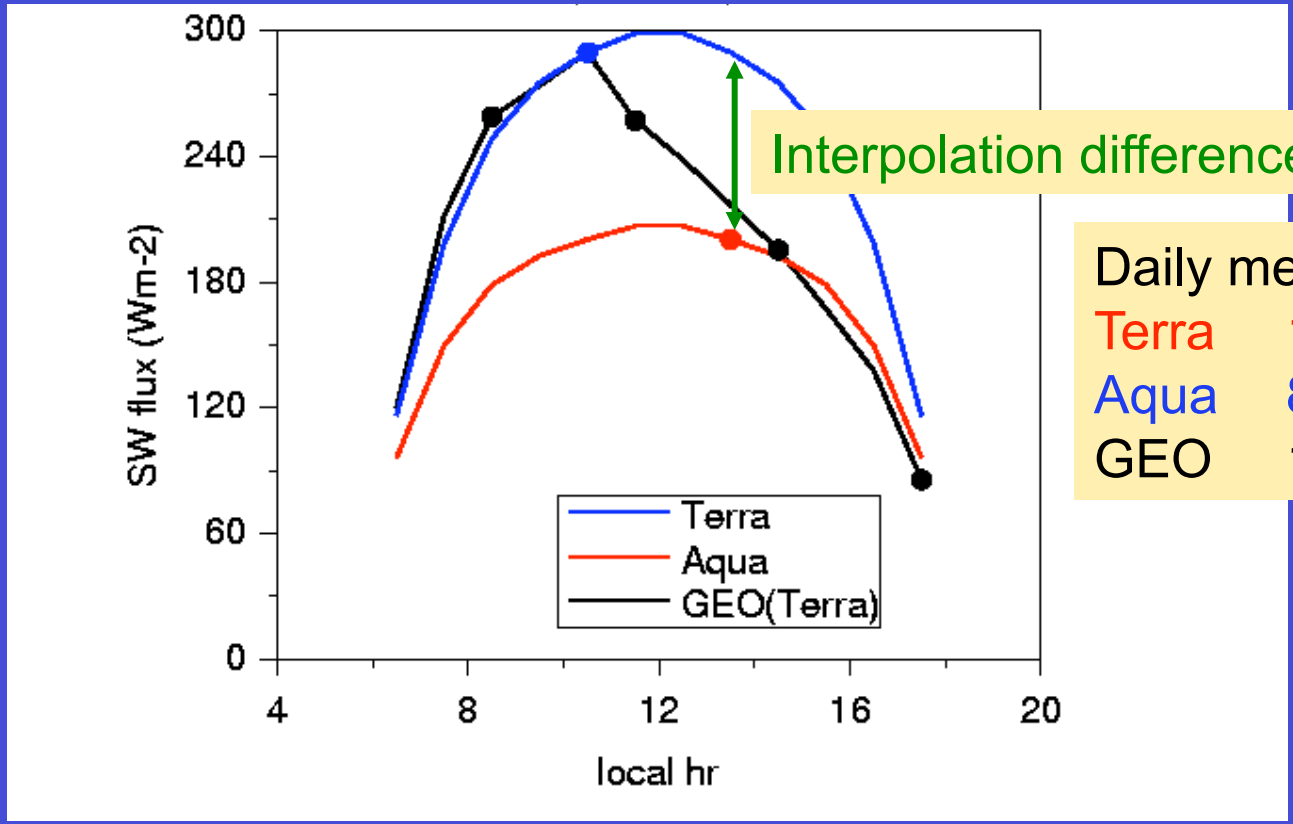
Terra SW hourly flux (ERBE temporal interpolation) which assumes constant meteorology at the 10:30 LT measurement time

Aqua SW hourly flux (ERBE temporal interpolation) which assumes constant meteorology at the 13:30 LT measurement time

Terra CERES 10:30 LT & 3-hourly GEO SW hourly flux (GEO temporal interpolation)

• The Terra 10:30 and Aqua 13:30 cannot replicate diurnal coverage
• Use Geostationary derived fluxes to complete diurnal coverage

The merged CERES/GEO SW diurnal flux



Daily mean (Wm-2)

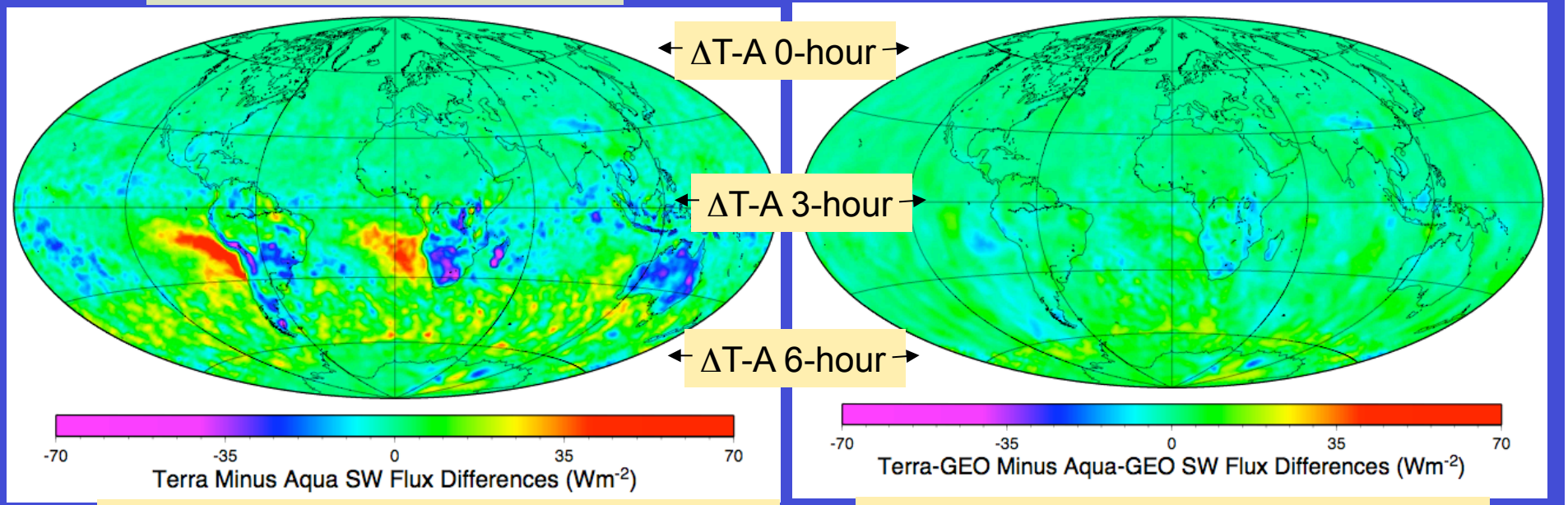
Terra	119.0
Aqua	85.4
GEO	102.3

- The Terra-Aqua daily flux difference is ~35Wm-2 for this maritime stratus region

Terra (10:30 LT) - Aqua (1:30 LT) monthly CERES SW flux differences Dec 2002

CERES only fluxes

CERES & GEO fluxes



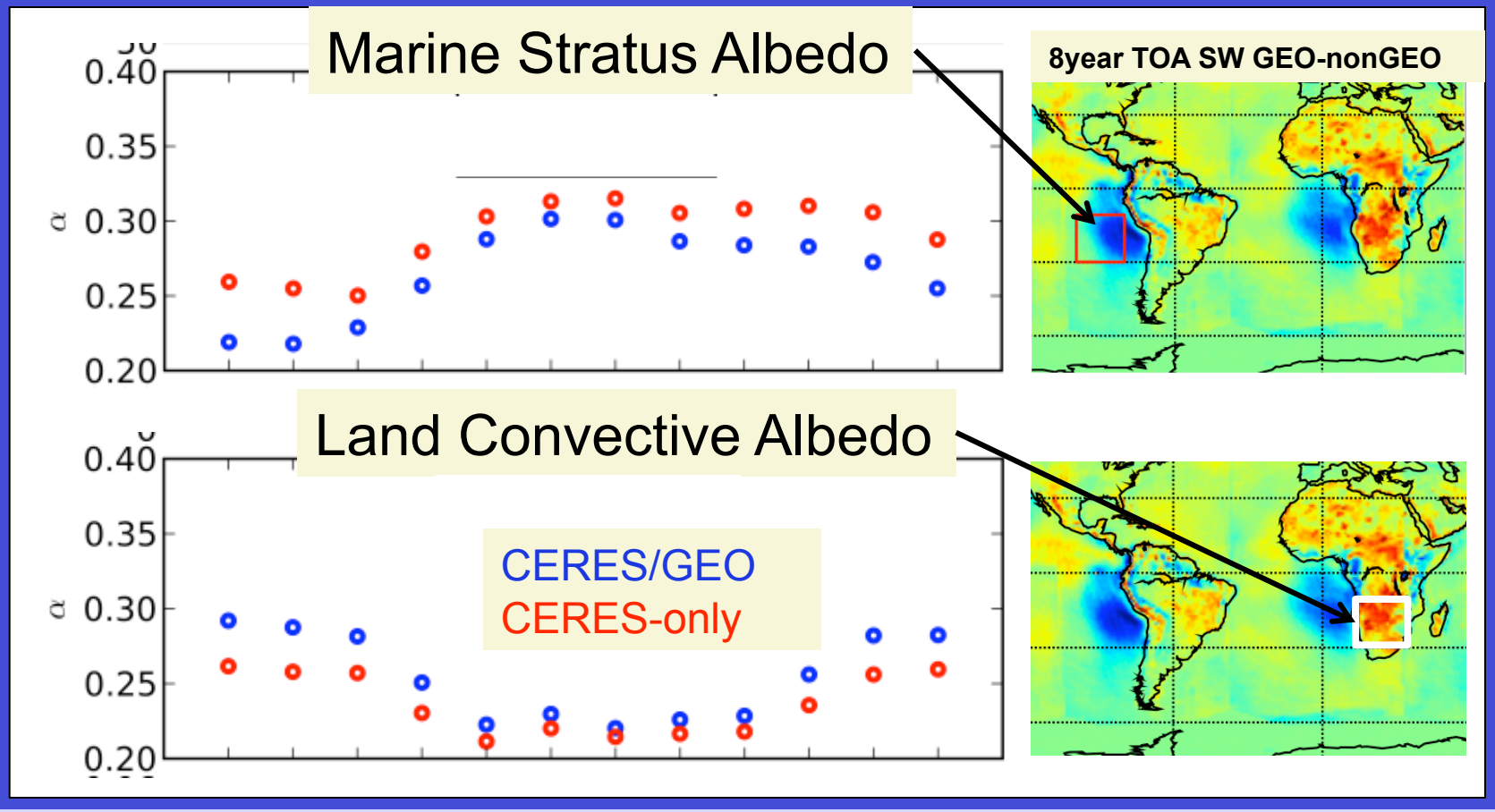
Regional rms=11.7 Wm^{-2} (11.1%)

Regional rms=4.6 Wm^{-2} (4.3%)

- Terra fluxes > Aqua fluxes over marine stratus regions (morning clouds)
- Aqua fluxes > Terra fluxes over land afternoon convection regions
- The merged GEO fluxes have removed the CERES sampling bias of the diurnal cycle

Courtesy of Lusheng and Norm

Annual Cycle of albedo from 8 years of Terra

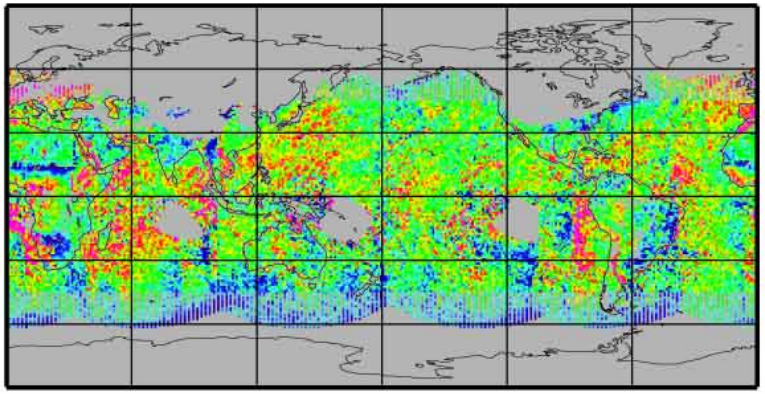


- Diurnal variation over marine stratus and land convection have a strong influence on the amplitude on the annual cycle of albedo
- Merging CERES with geostationary satellite fluxes captures both the diurnal and annual cycles of albedo

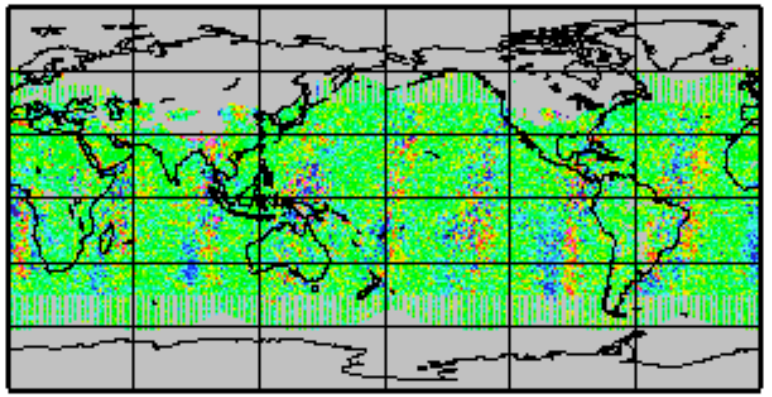
Regional SW biases (GEO - CERES) Jan01

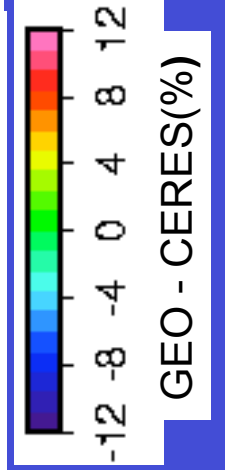
matched within a hour

Before Normalization, Jan01

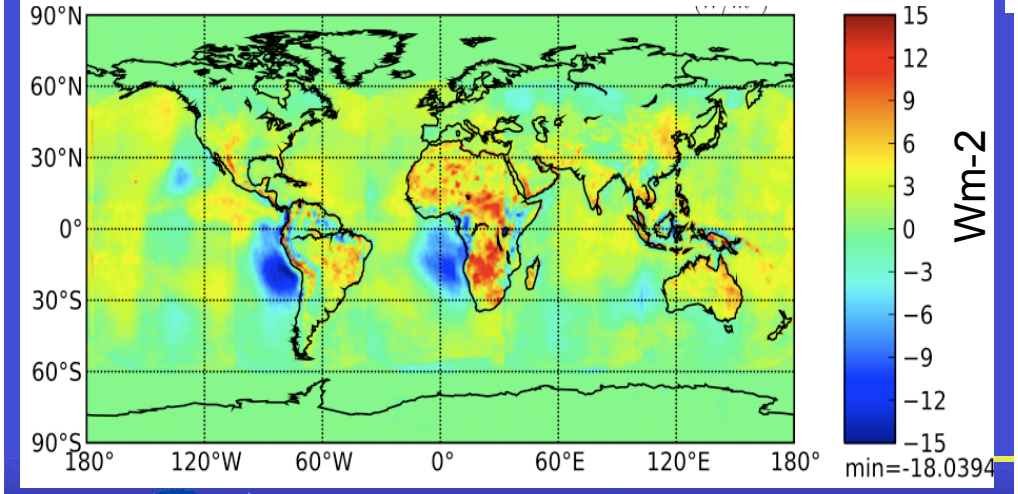


After Normalization, Jan01

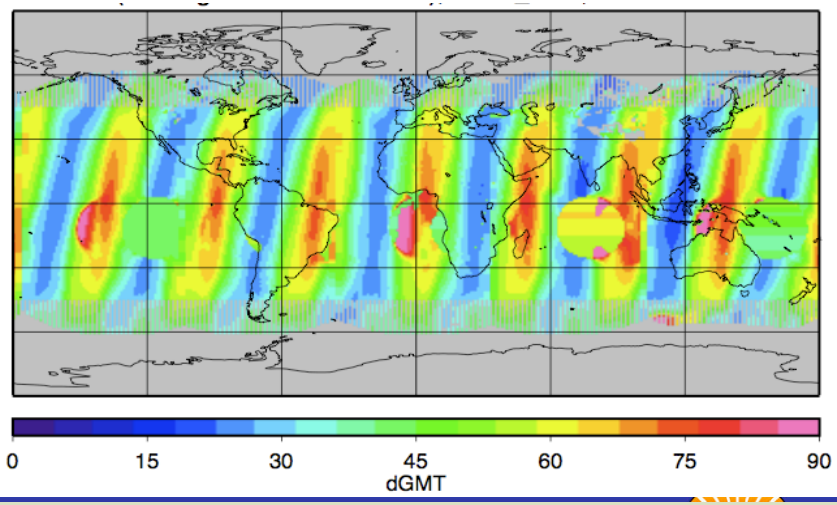




All-sky SW GEO-nonGEO, 8-year mean



Normalization Time difference, Dec02



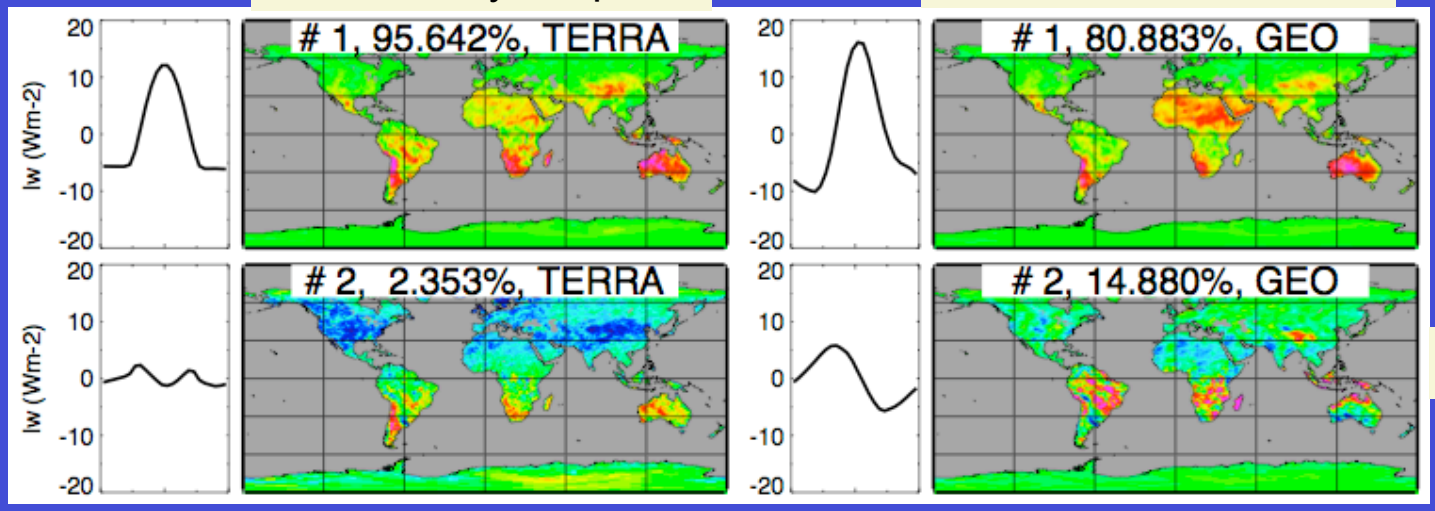
- 3-hourly SW normalization limited by time difference of matches, however global mean bias<0.1%
- Quantify 1-hourly GEO over 3-hour GEO derived flux improvements

EOF analysis, LW Land and Ocean, Jan 2005

– Perform EOF analysis on Jan 2005 1° gridded monthly SW and LW monthly hourly fluxes

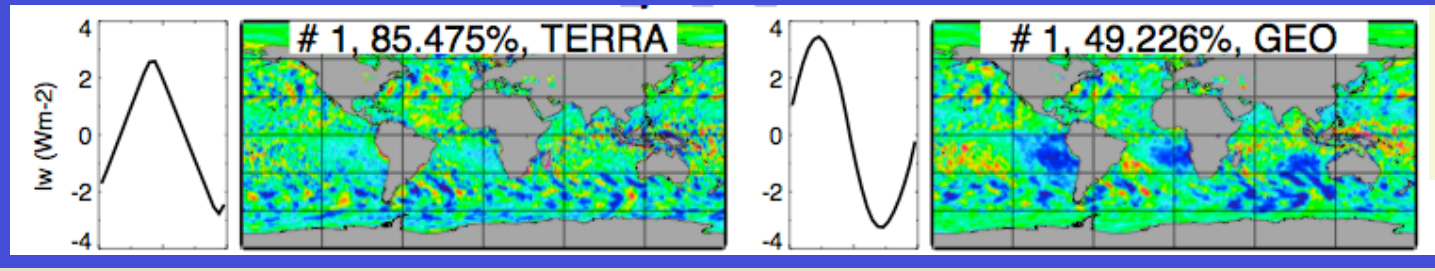
CERES-only temporal

GEO/CERES temporal



Land diurnal heating

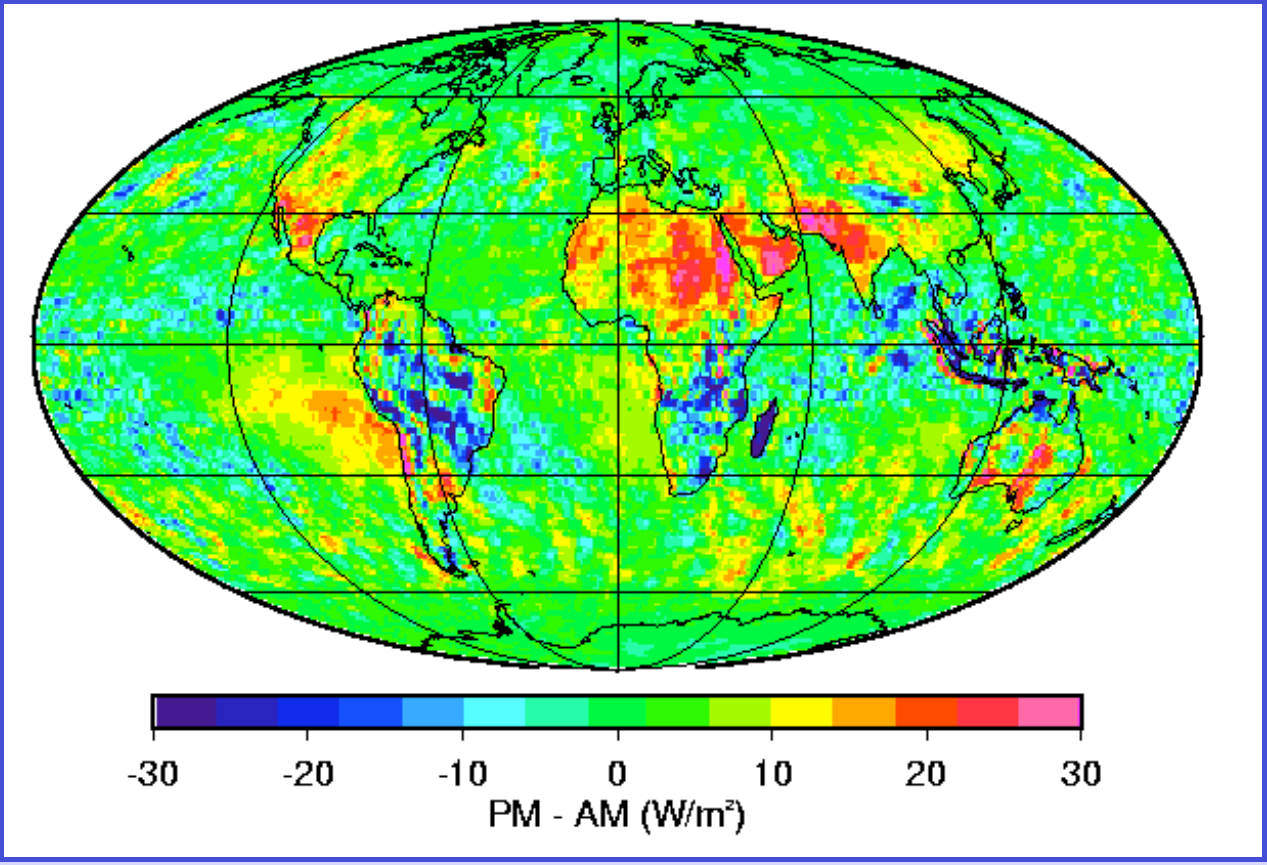
Afternoon convection

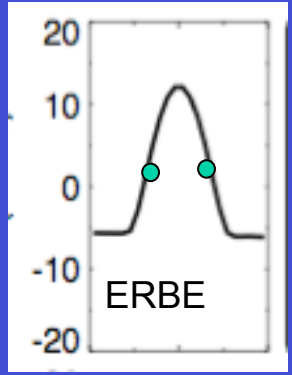


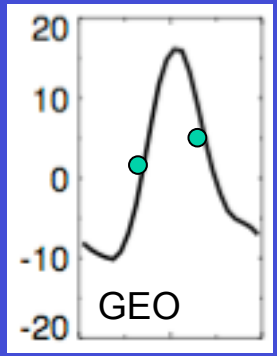
Both methods use linear interpolation over ocean

- 2nd EOF shows that GEO captures the afternoon convection, ERBE 2nd EOF < 2.5% contribution
- Terra sampling cannot resolve maritime stratus LW diurnal cycle

GEO LW 16:30 (PM) - 7:30 (AM) monthly hourly mean Dec 2002



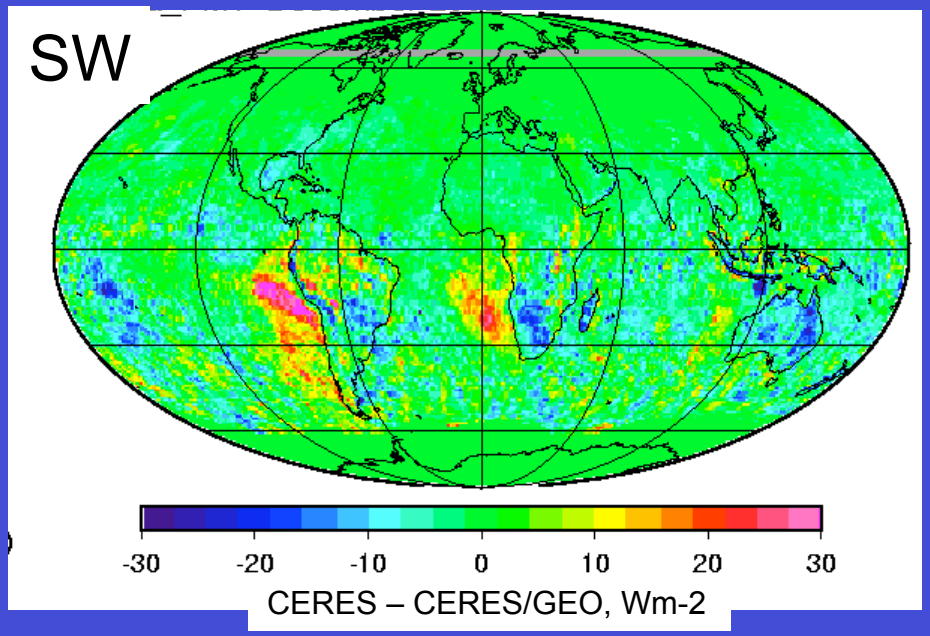


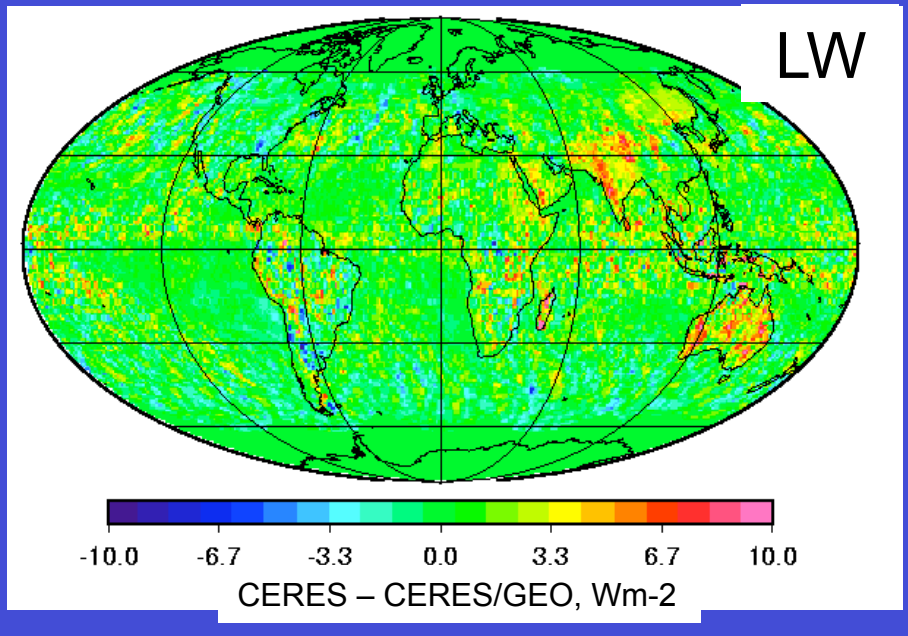


- ERBE LW temporal averaging is symmetric about noon
- Plotted is the PM-AM difference symmetric about noon for GEO temporal averaging
- For land: blue afternoon convection, red diurnal heating, thermal lag
- PM-AM differences can be ~ 30 Wm^{-2}

Terra CERES – CERES/GEO monthly mean Dec 2002

- CERES = CERES fluxes and ERBE (constant meteorology) temporal averaging
- CERES/GEO = CERES fluxes utilizing GEO fluxes for temporal interpolation





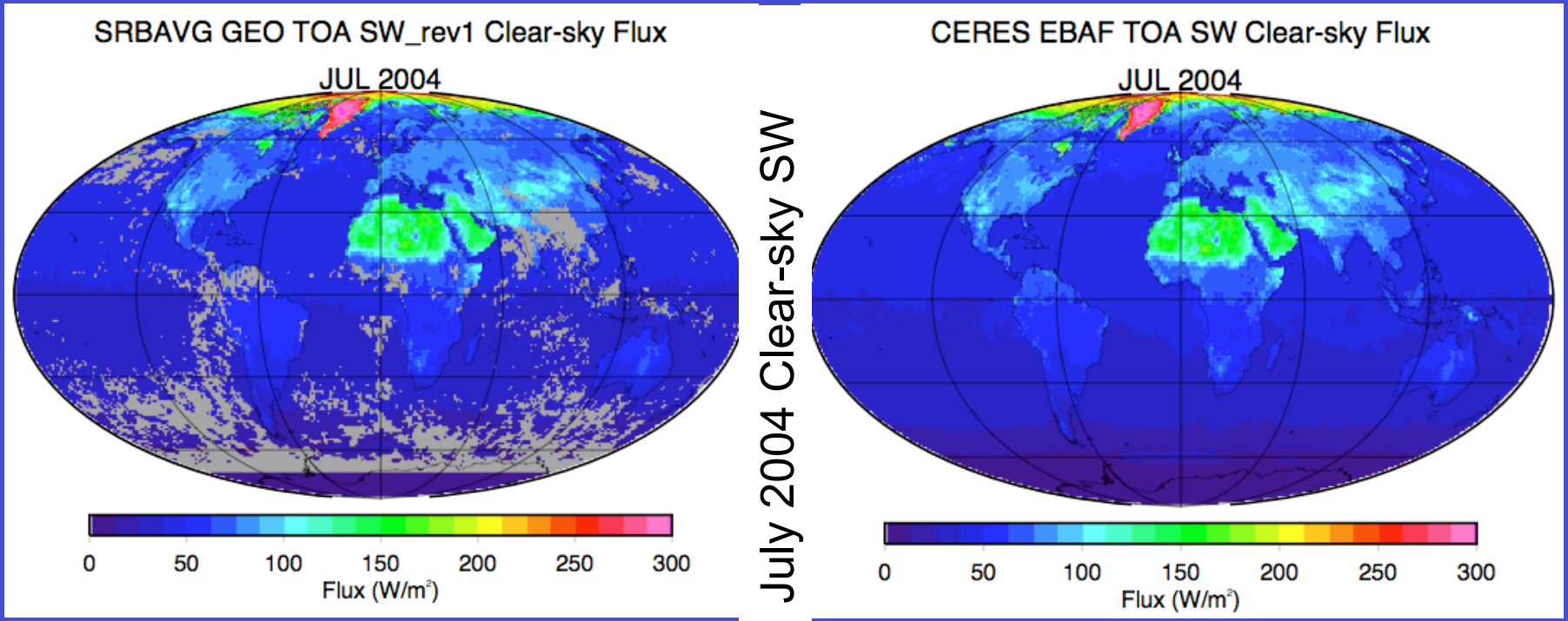
- Some regional monthly differences > 20 Wm^{-2}
- Global bias is - 1.0 Wm^{-2}

- Global bias = 0.5 Wm^{-2}
- Day and night LW biases compensate

EBAF clear-sky filling

SRBAVG-GEO

EBAF

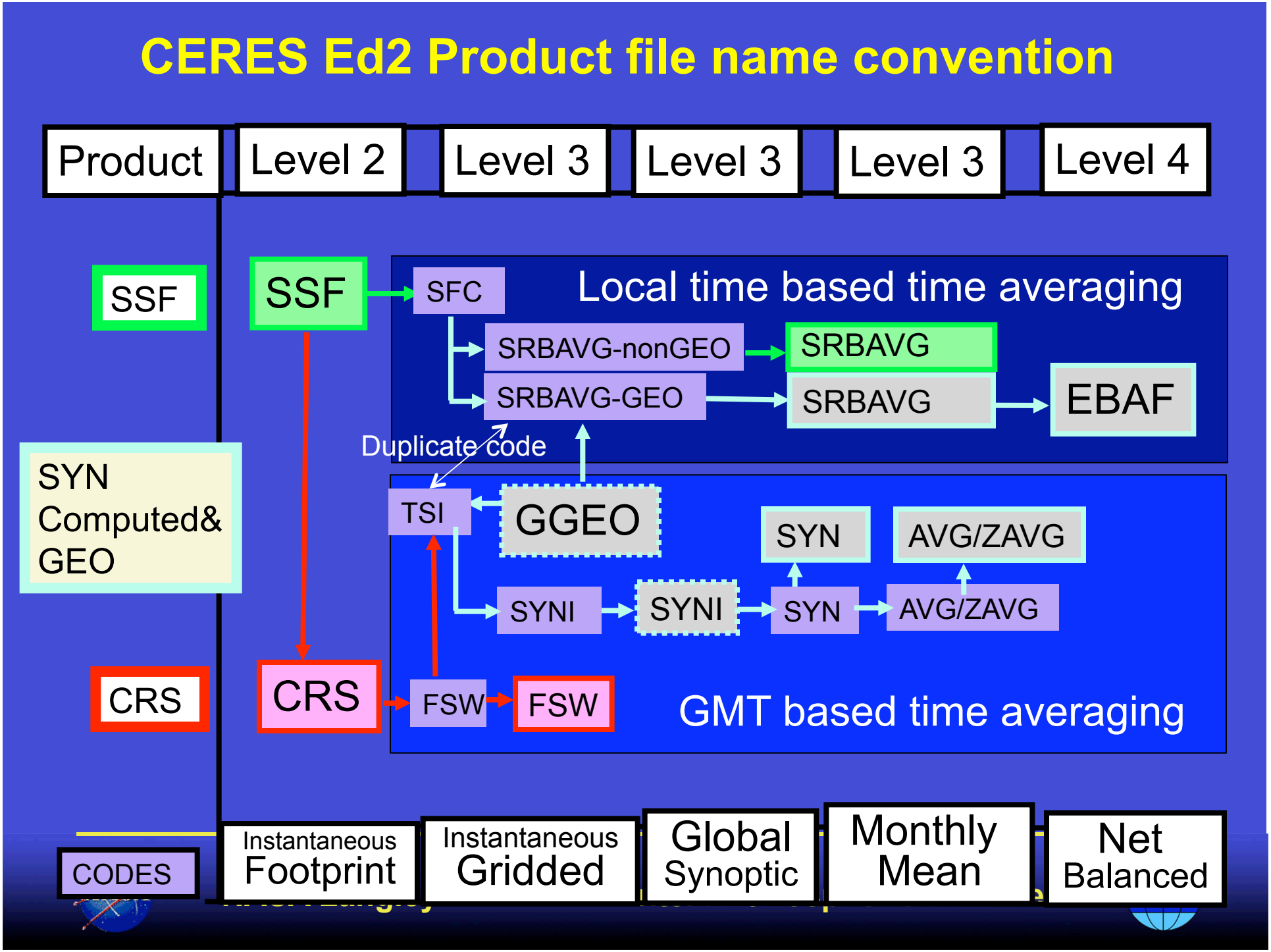


- Note the amount of missing clear-sky SW regional fluxes
- CERES requires that 99% of the MODIS pixels within a CERES footprint are clear to be classified as clear-sky
- Missing clear-sky fluxes are based on MODIS derived broadband clear-sky pixel radiances

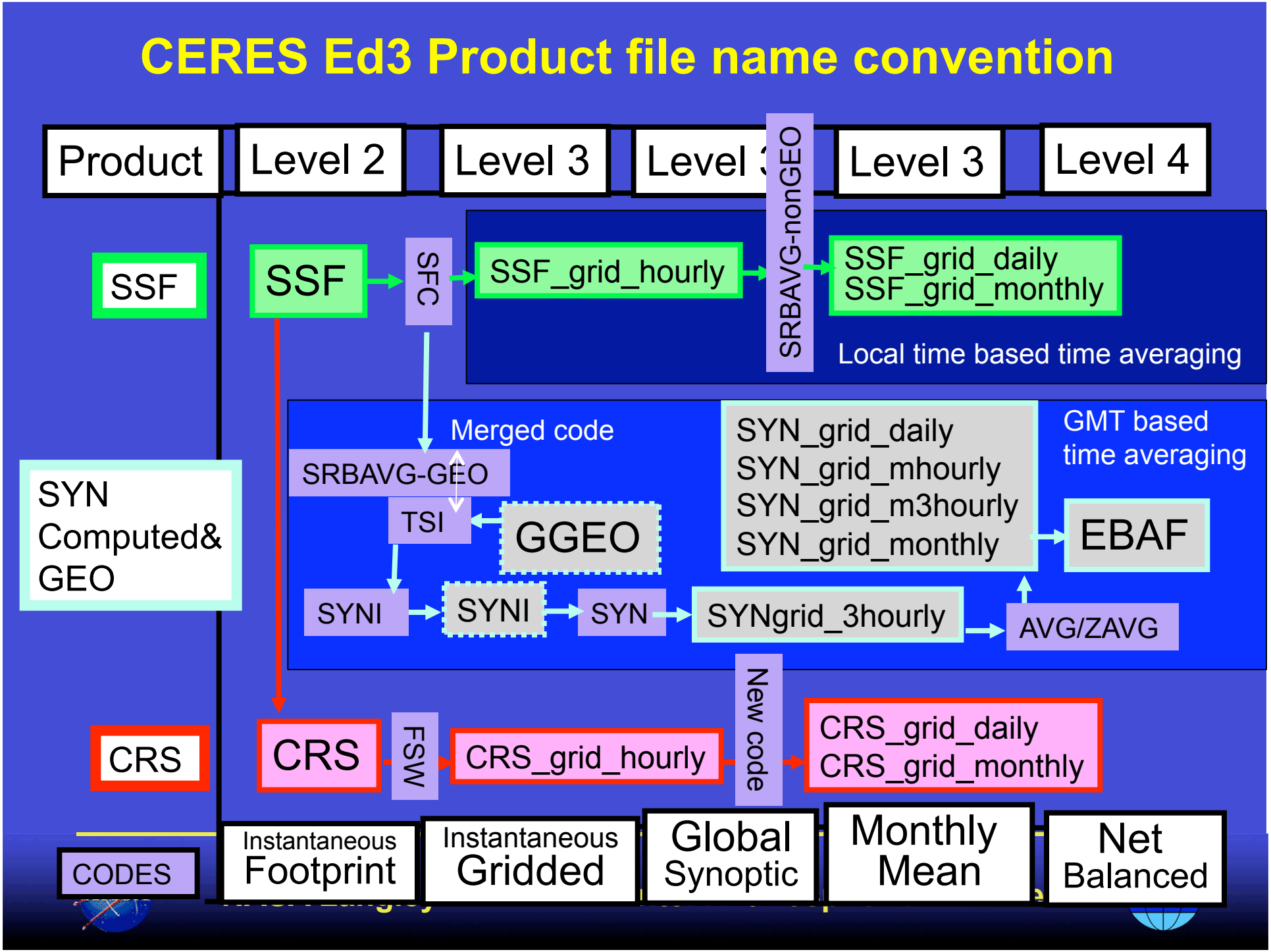
CERES Ed2.5 lite products

- Edition3 CERES instrument calibration processed with Edition2 algorithms (clouds, ADMs, etc)
  - All known instrument artifacts removed
  - Will use Solar Radiation and Climate Experiment (SORCE) incoming solar as well as the Edition 3 products (~1361 Wm^{-2})
- Designed to give users a quick look into the CERES Edition 3 product fluxes
  - SSF1deg (nonGEO), SYN1deg (GEO) and EBAF available
  - Terra from Mar 2000 to Feb 2010, Aqua from Jul 2002 to Jun 2008
  - Reduce parameter dataset, Monthly and Daily resolution
  - All lite improvements to migrate to Edition3 TISA products
  - SYN1deg SW and LW clear-sky fluxes are nonGEO
- Available on CERES prototype ordering tool as beta
  - Soon to be released as Edition 2.5 for publication and at ASDC
  - All 10 years can be ordered as one netCDF file on tool (0.6GB)

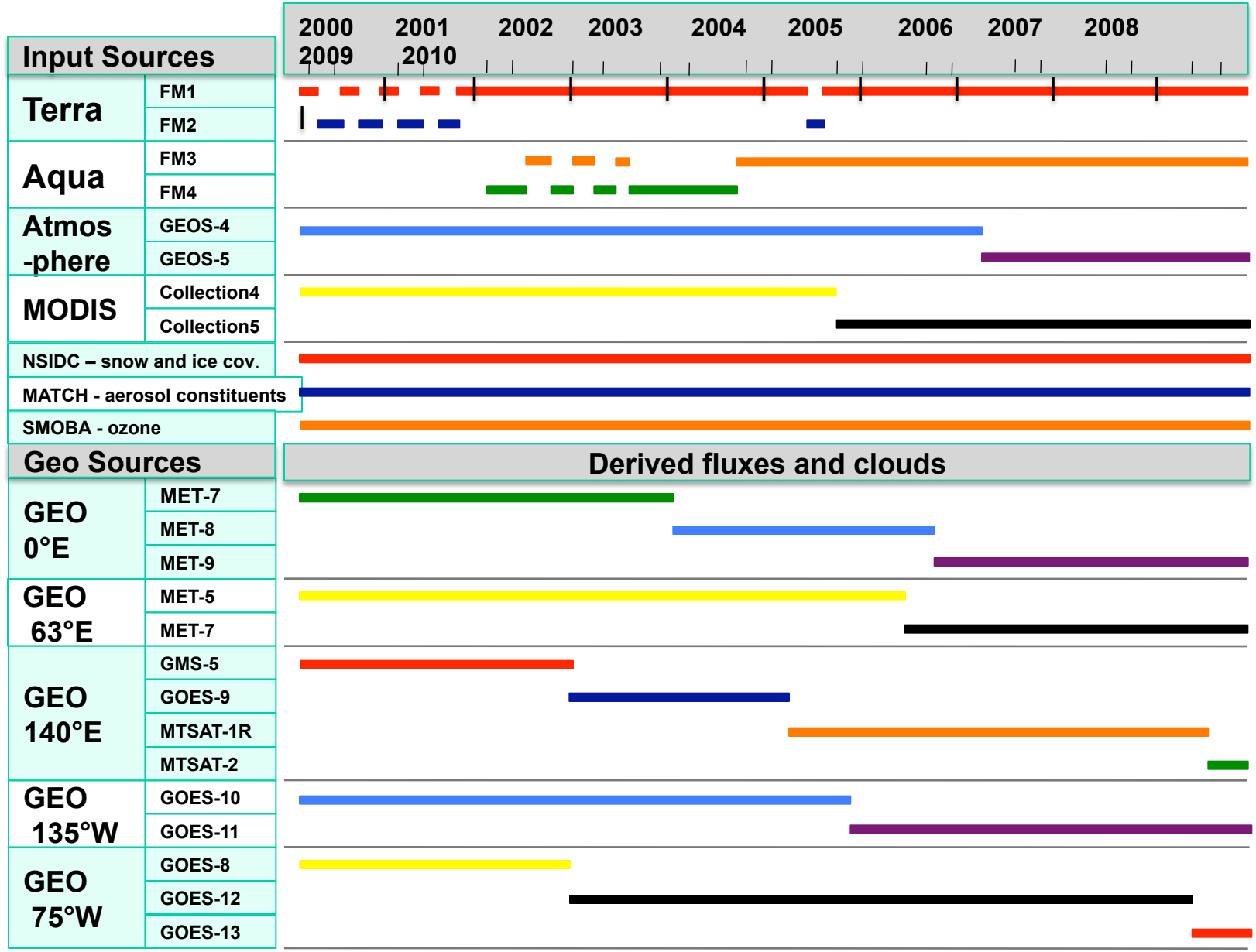
CERES Ed2 Product file name convention



CERES Ed3 Product file name convention



CERES Input Datasets



GEO calibration update

- Recalibrate all GEOs to MODIS between 2000-2010 for complete time records for Edition4 GEO coefficients delivery
  - Currently (Edition2) piece wise (3-year increments) calibration coefficients are delivered
  - Take into account spectral response differences using SCIAMACHY
  - Use desert and DCC to monitor stability of GEO's

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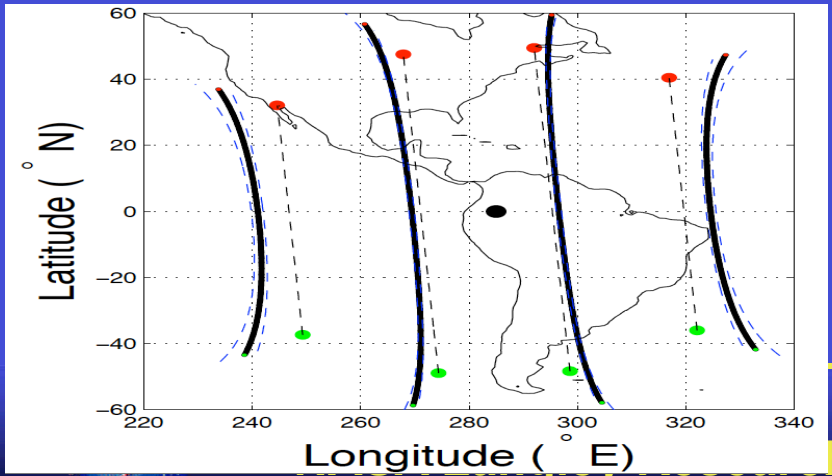
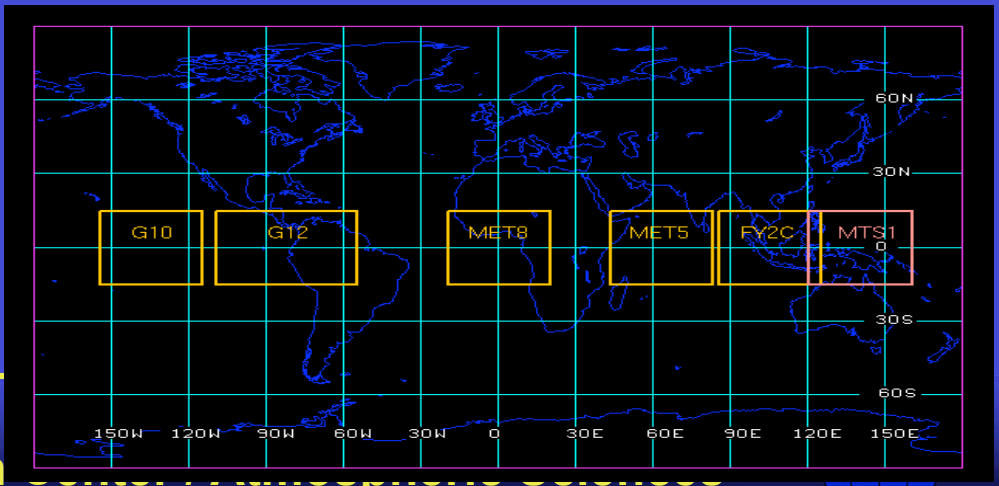
GEO to MODIS Cross-Calibration Method

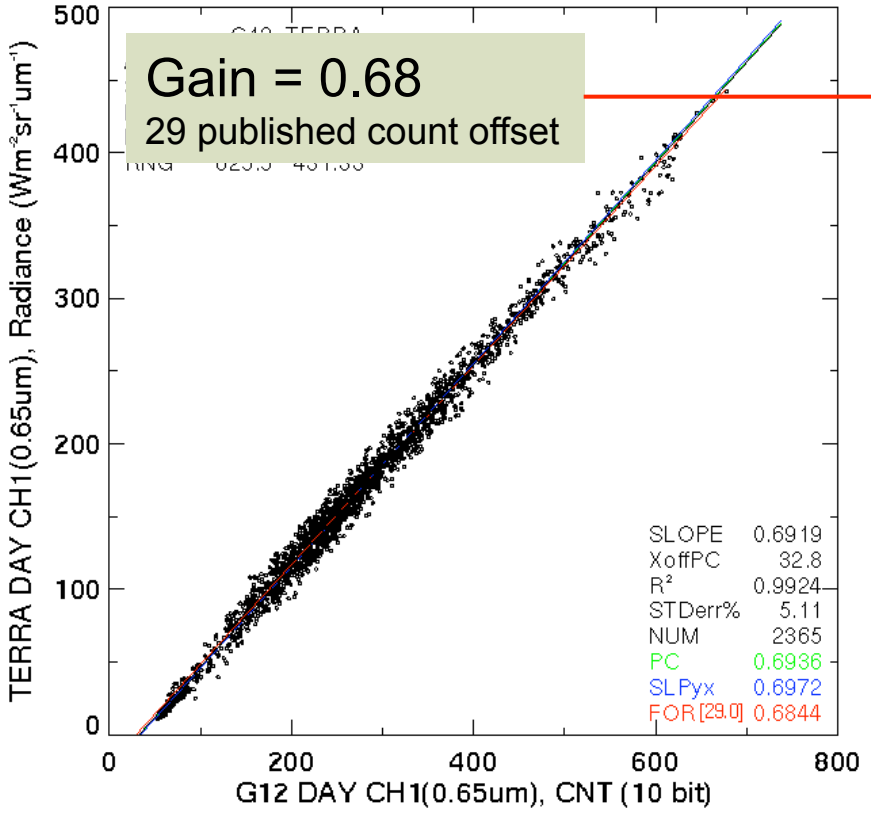
- Ray-match coincident GEO counts (proportional to radiance) and MODIS radiances
  - use a 0.5°x0.5° lat by lon grid to mitigate navigation and time matching errors
  - Use MODIS as reference since GEOs have no onboard calibration
  - Normalize solar constants and SZA, obtain MODIS equivalent radiance
- Perform monthly GEO/MODIS regressions of the gridded radiances, and derive monthly gains
- Compute timeline trends from the monthly gains



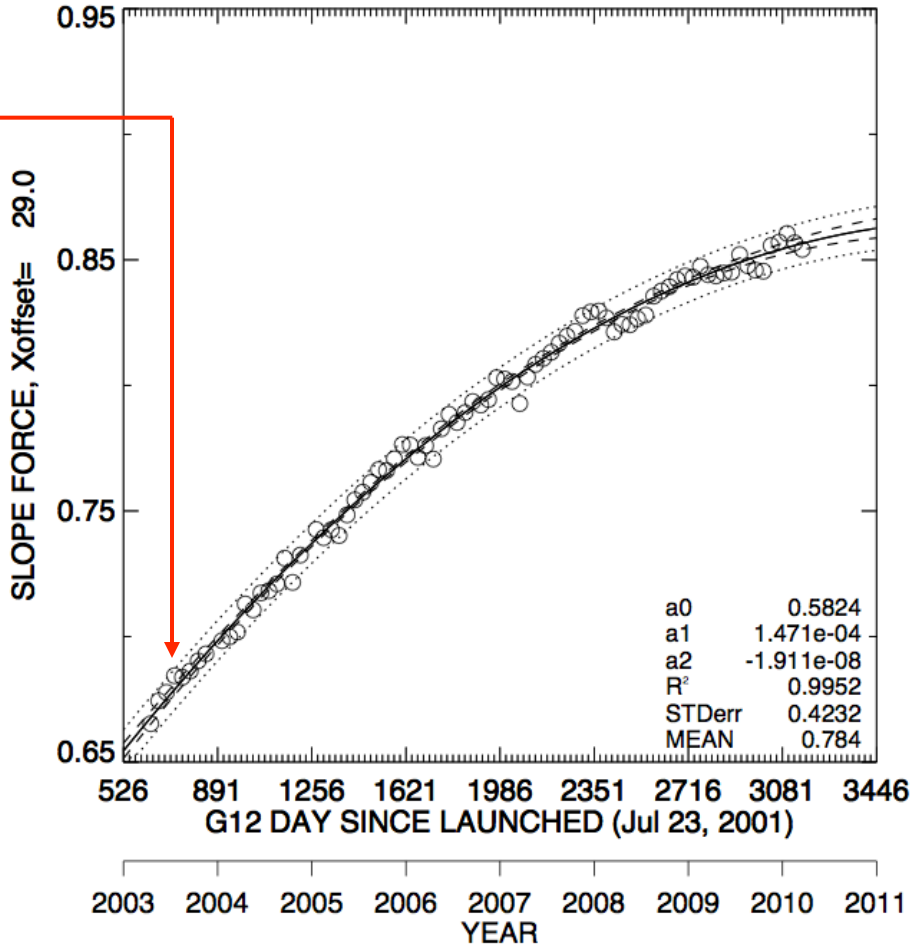


GOES-12/Terra-MODIS

GOES-12/Terra-MODIS July 2003

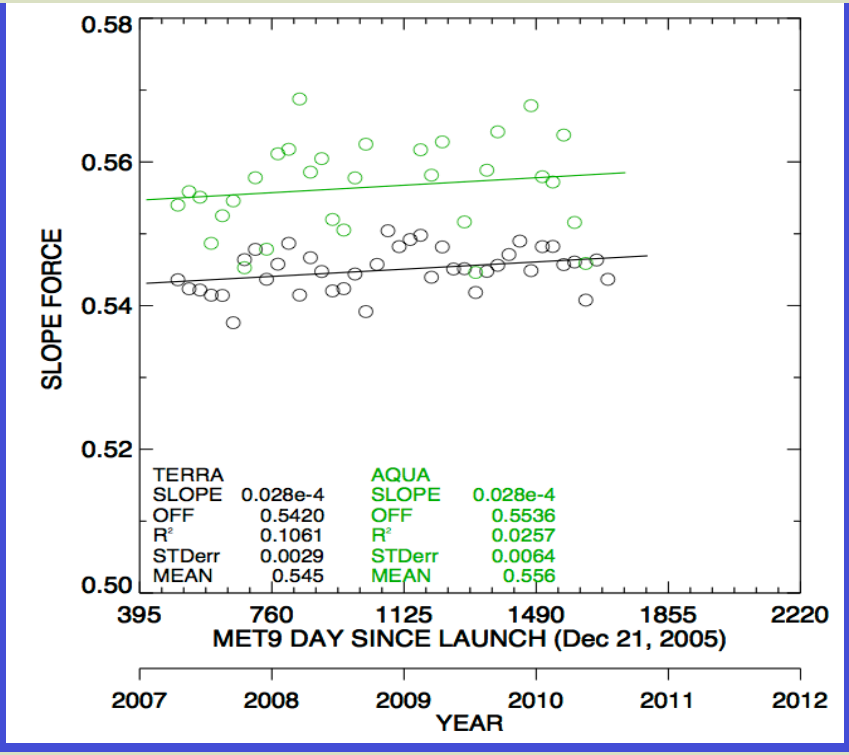


GOES-12 gain based on Terra-MODIS

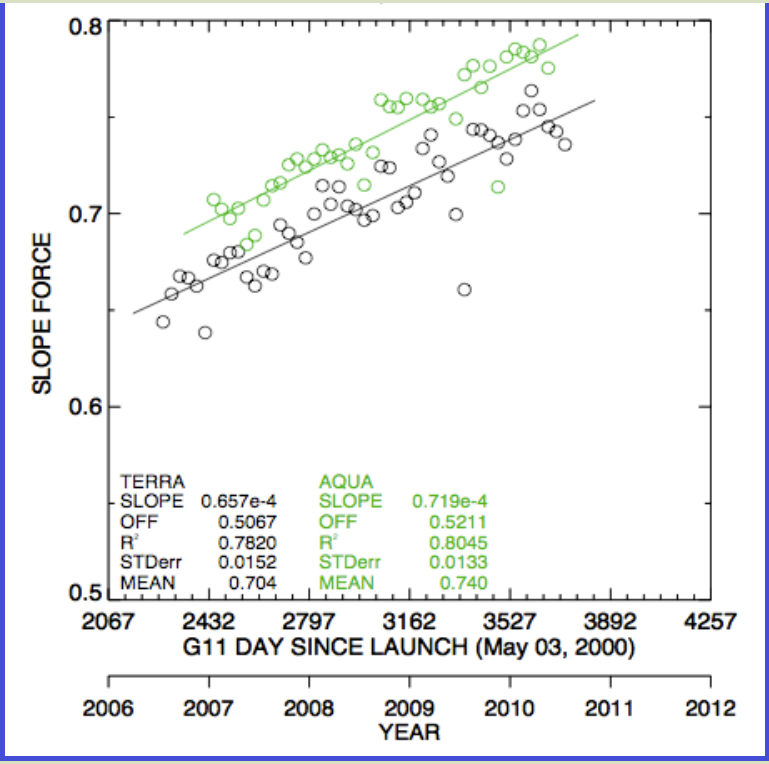


GEO/MODIS Validation

Met-9/Terra & Aqua MODIS



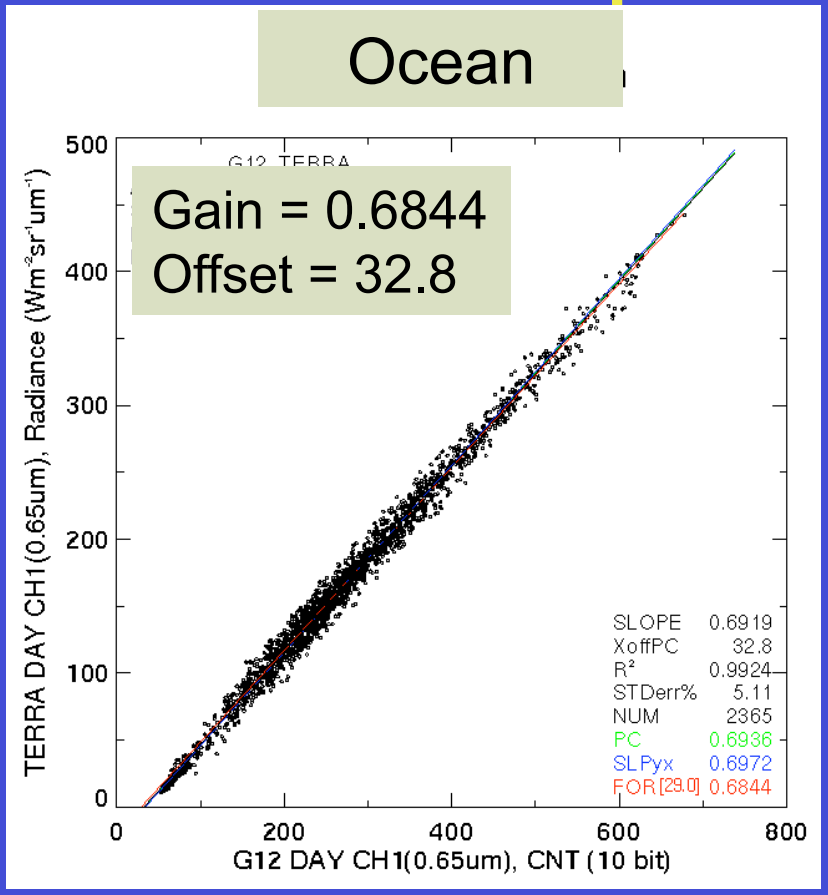
GOES-11/Terra & Aqua MODIS



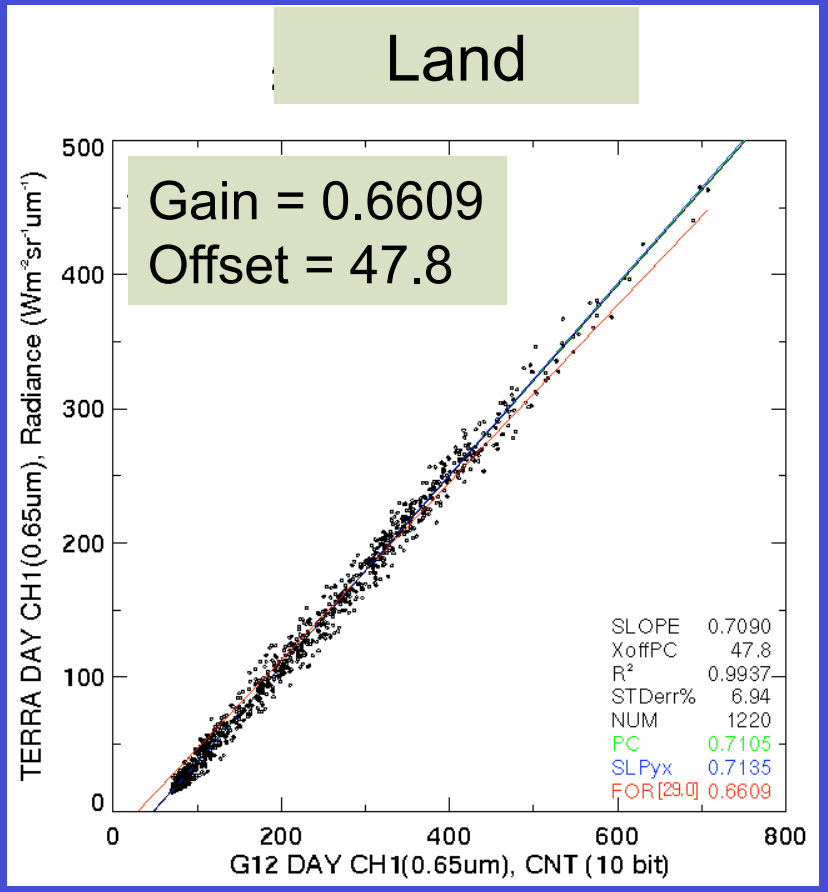
- Note that Terra and Aqua MODIS use solar diffusers to maintain calibration stability
- It is remarkable that both Terra and Aqua give a ~0.2% degradation/year
- These plots indicate a 2% calibration difference between Terra and Aqua, the ~ absolute calibration uncertainty of MODIS

GOES-12/Terra-MODIS, July 2003
no spectral correction

Ocean



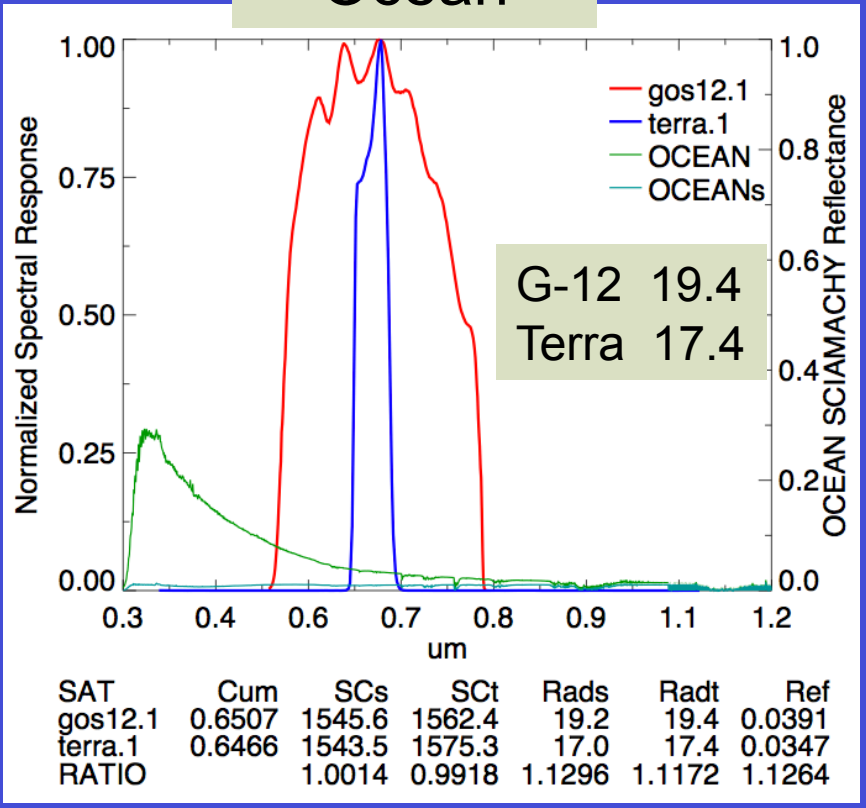
Land



- GEO gain dependent on instrument spectral response and scene type
- Note surface type effects mainly the offset under clear-sky conditions
- The gain difference is 3%, and the offset should be 29.0

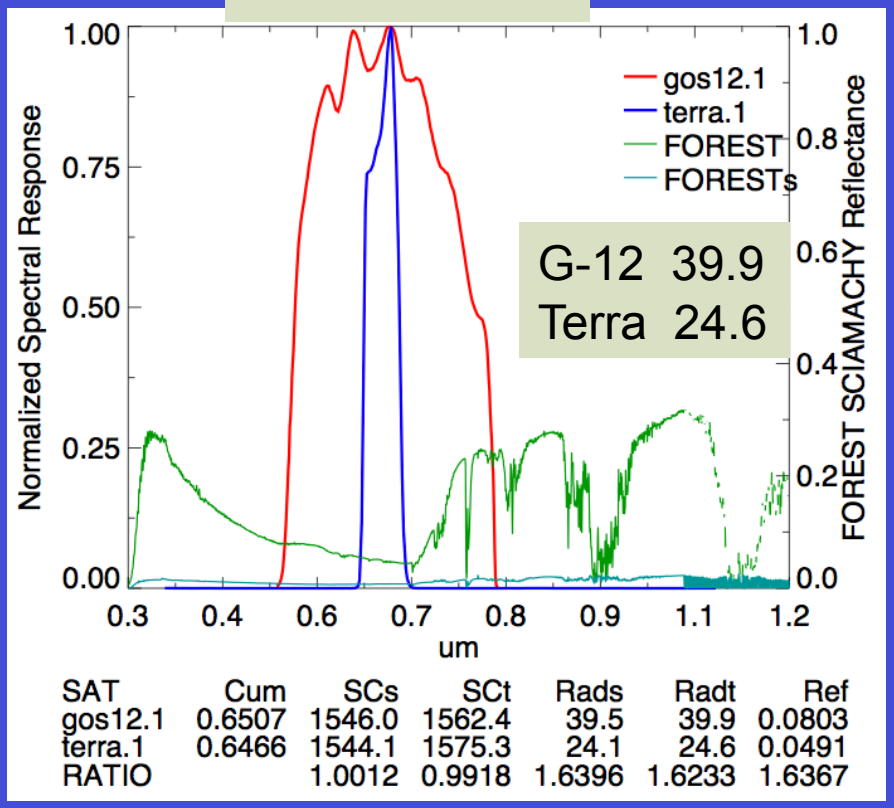
SCIAMACHY* spectra

Ocean



SAT	Cum	SCs	SCt	Rads	Radt	Ref
gos12.1	0.6507	1545.6	1562.4	19.2	19.4	0.0391
terra.1	0.6466	1543.5	1575.3	17.0	17.4	0.0347
RATIO		1.0014	0.9918	1.1296	1.1172	1.1264

Forest



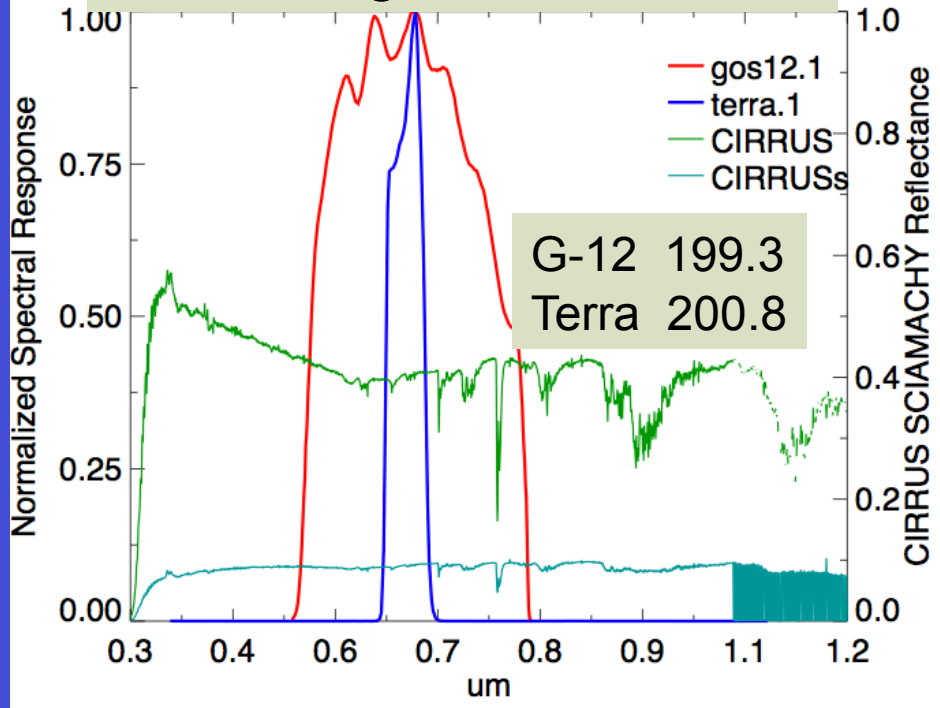
SAT	Cum	SCs	SCt	Rads	Radt	Ref
gos12.1	0.6507	1546.0	1562.4	39.5	39.9	0.0803
terra.1	0.6466	1544.1	1575.3	24.1	24.6	0.0491
RATIO		1.0012	0.9918	1.6396	1.6233	1.6367

- Clear-sky SCIAMACHY mean & sigma spectral response over ocean and forest
- Compute the Radiance using Thuillier incoming solar

*Courtesy of SCIAMACHY team

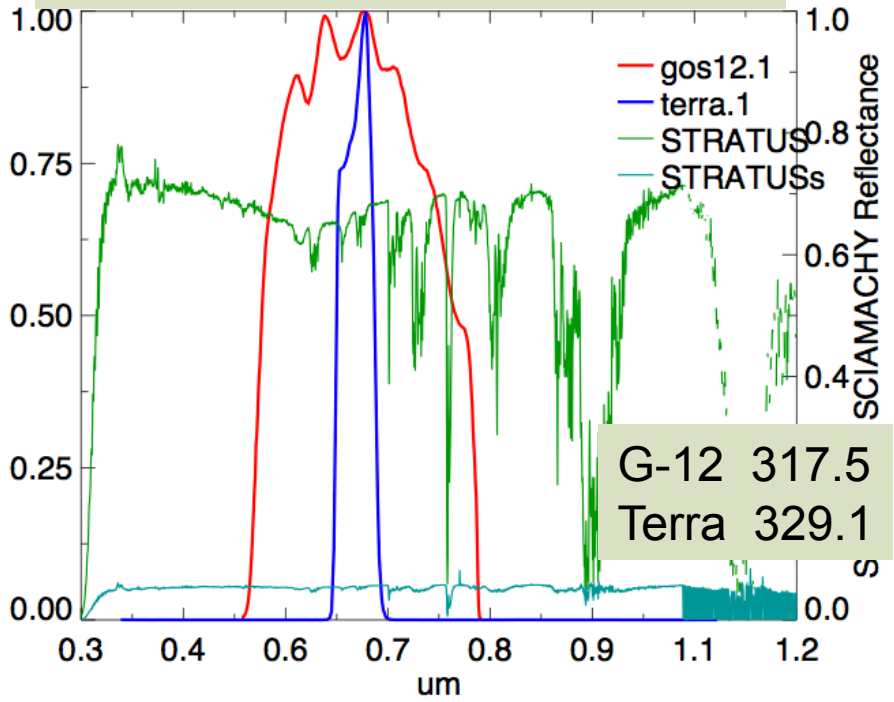
SCIAMACHY* spectra

High Cloud



SAT	Cum	SCs	SCt	Rads	Radt	Ref
gos12.1	0.6507	1545.1	1562.4	197.1	199.3	0.4008
terra.1	0.6466	1543.0	1575.3	196.6	200.8	0.4004
RATIO		1.0013	0.9918	1.0025	0.9927	1.0009

Low Cloud

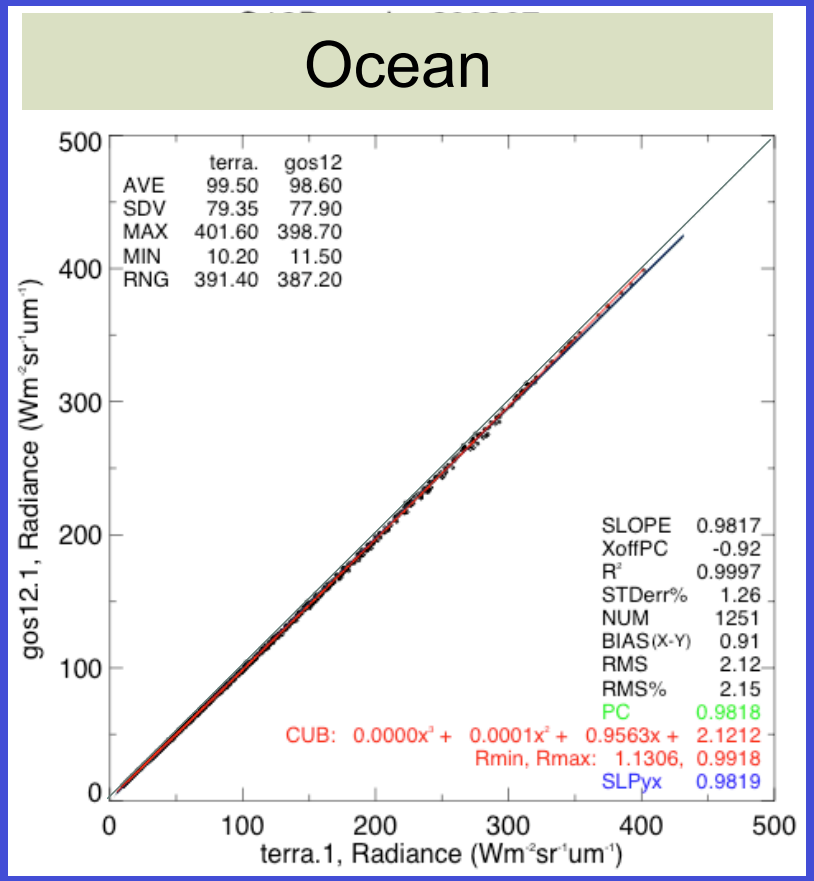


SAT	Cum	SCs	SCt	Rads	Radt	Ref
gos12.1	0.6507	1546.4	1562.4	314.3	317.5	0.6385
terra.1	0.6466	1544.4	1575.3	322.4	329.1	0.6564
RATIO		1.0013	0.9918	0.9748	0.9647	0.9727

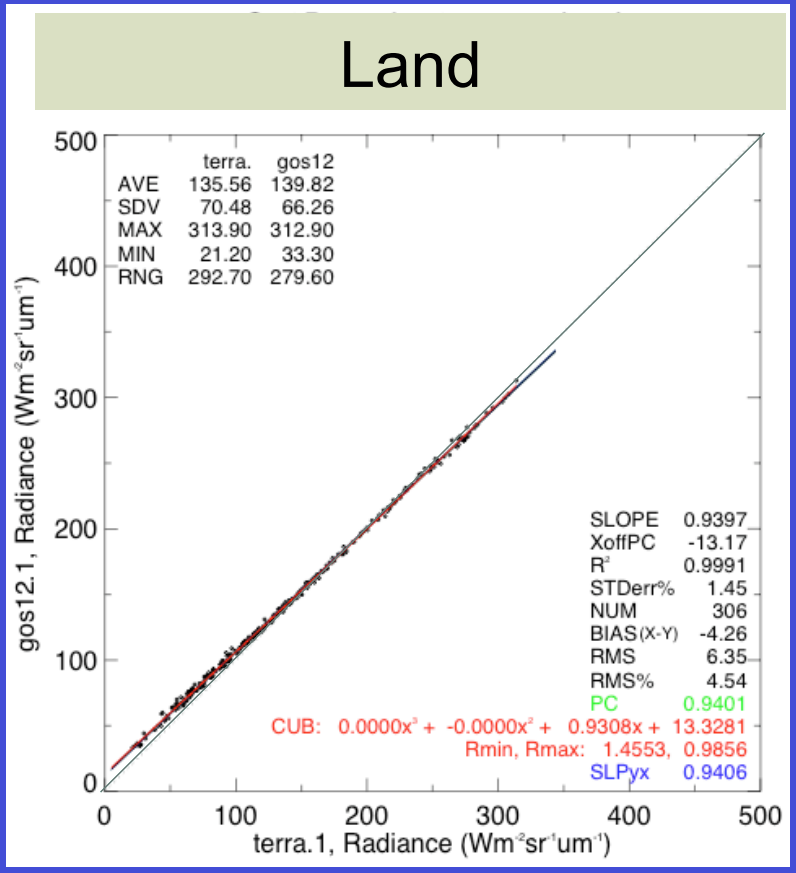
- Bright cold high clouds have radiance ratios near one
- Bright low clouds have more absorption in the near IR

SCIAMACHY spectral corrections, July 2003

Ocean



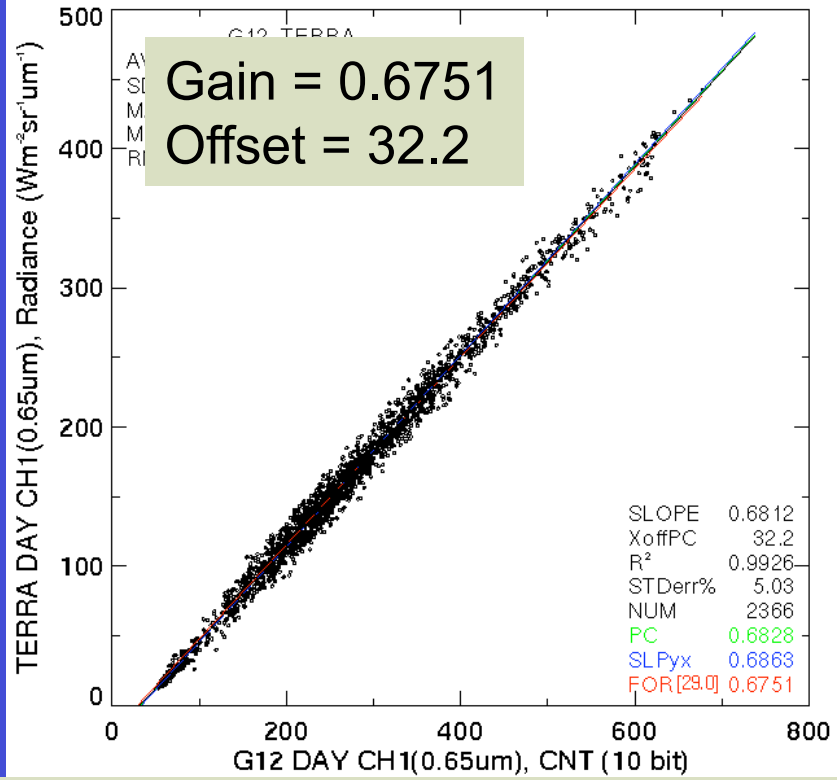
Land



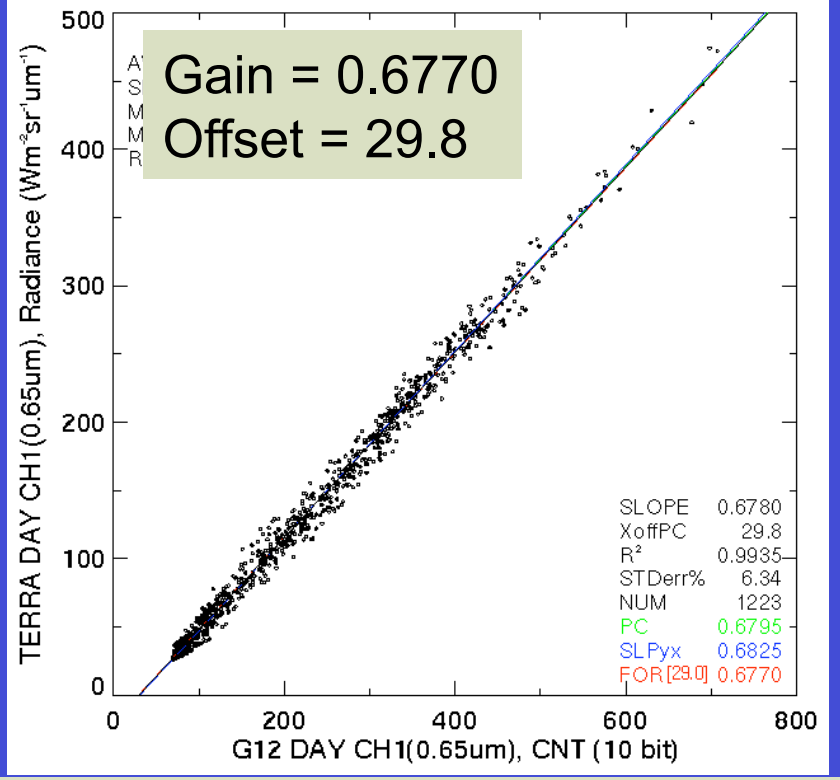
- Use all SCIAMACHY footprints that fall into the GEO equatorial domain during
- Derive spectral correction using a cubic fit for ocean and water

GOES-12/Terra-MODIS, July 2003 with spectral correction

Ocean



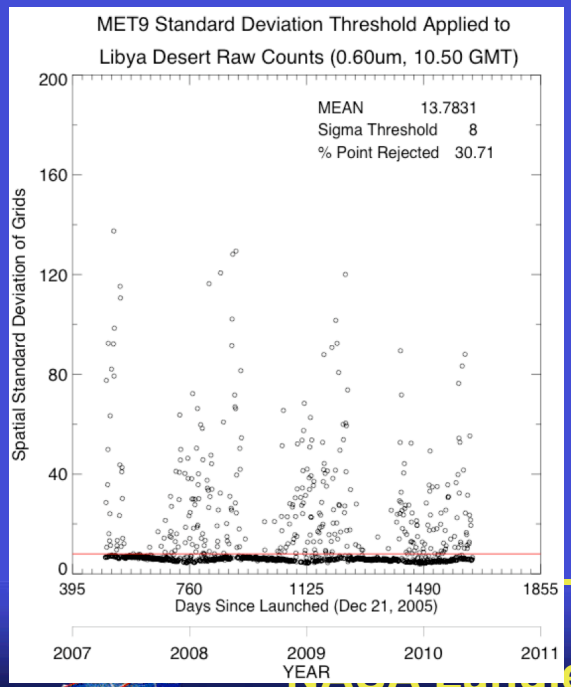
Land

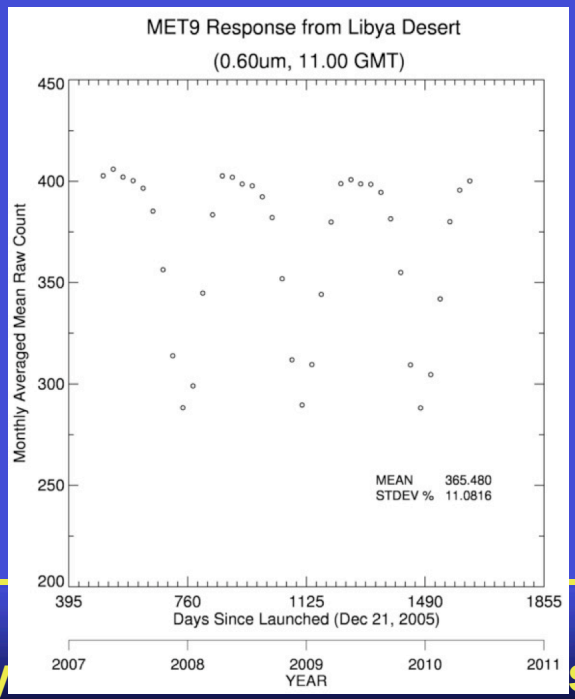


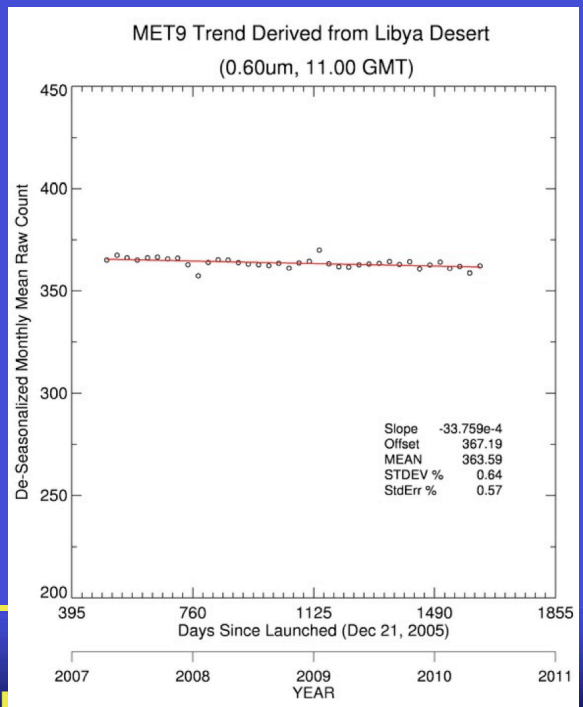
- The gain difference before spectral correction = 3%, offset=32.8, 47.8
- With spectral correction the gain difference = 0.3%, offset close to 29

Desert (relative) calibration method

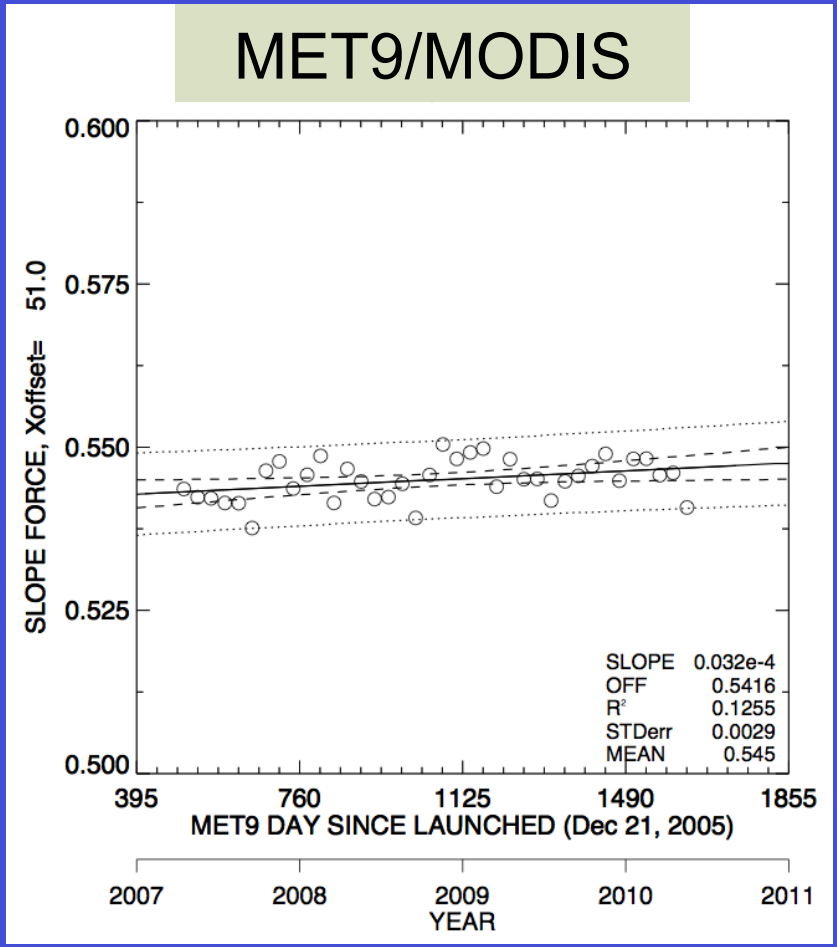
- Identify invariant sites over GEO domains
- Apply spatial sigma of VIS and IR radiance threshold to identify clear-sky over site using daily noon images
- Average daily GEO counts (proportional to radiance) to derive monthly means and deseasonalize

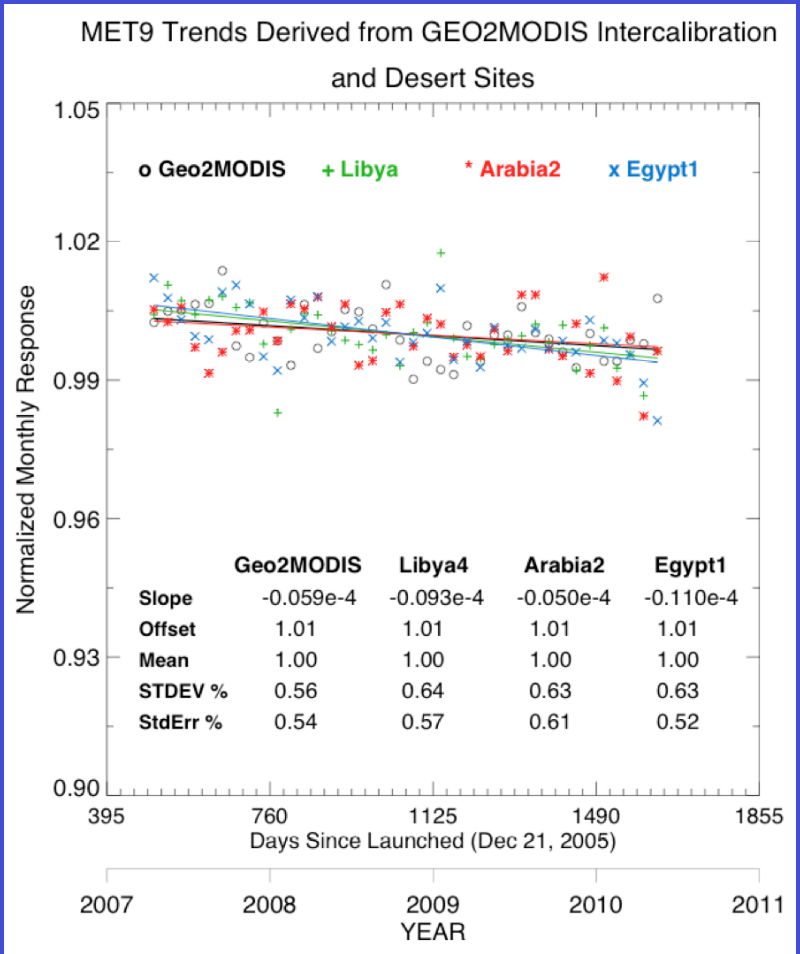






Compare desert and MODIS MET-9 VIS degradation

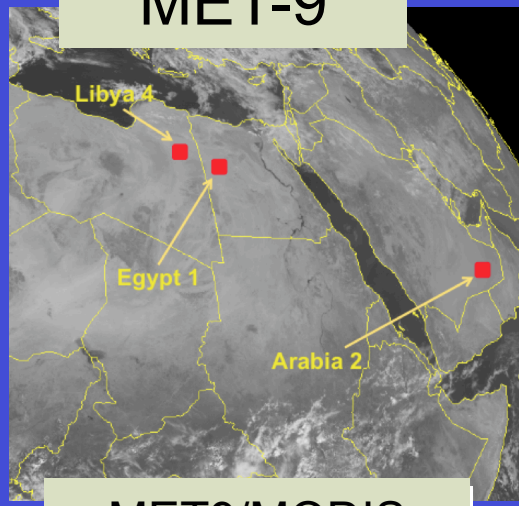




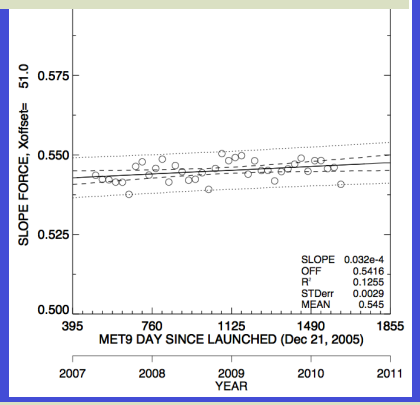
- All desert site calibration degradations are within the uncertainty of the regressions
- The sigma of the MET-9/MODIS and MET9/desert degradation is similar

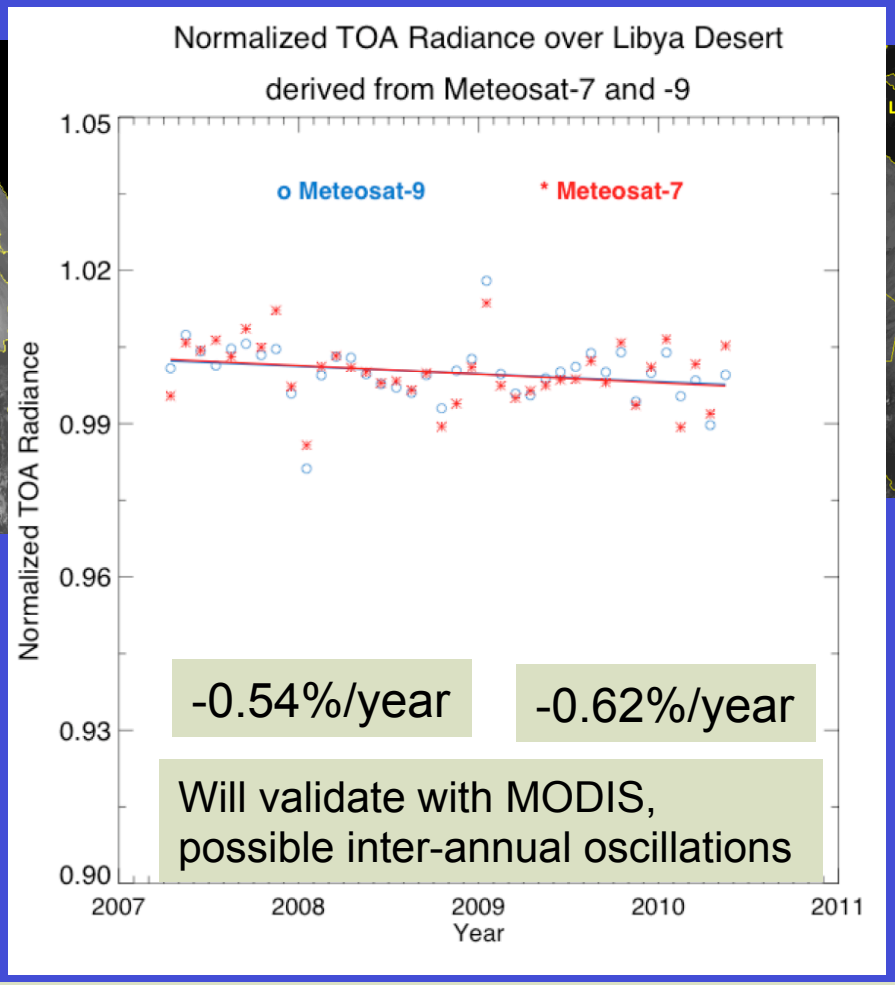
MET-9 & MET-7 Libyan desert calibration comparison

MET-9

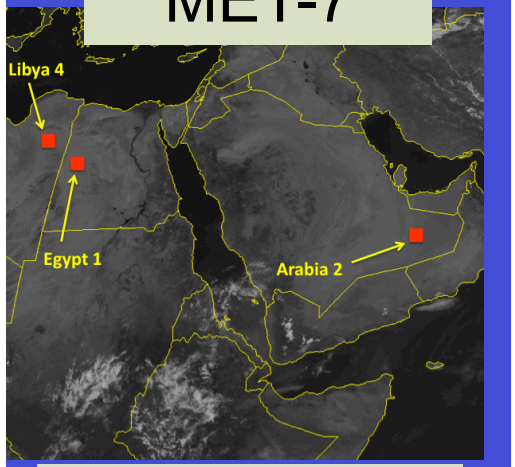


MET9/MODIS

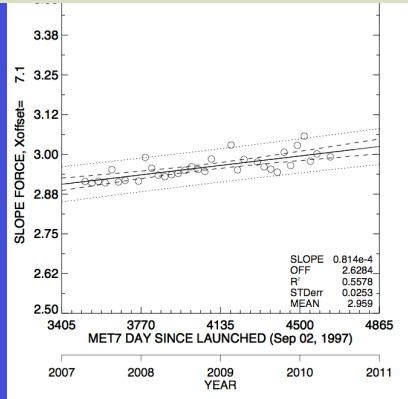




MET-7



MET7/MODIS



- Apply GEO/MODIS calibration to desert site and monitor site stability

Note how well the MET-9 and MET-7 monthly means track each other, which indicates the robustness of the method.

CERES Prototype Ordering Tool

"I think it is important that NASA delivers the data to the US public, obtained with their tax dollars, in a way that are useful for greater good and do not remain confined to only a selected group. "

(User comment, August 24, 2009)

D. Doelling

NASA LaRC

C. Chu, E. Kizer, C. Mitrescu, E. Heckert

SSAI

CERES Tiger Team

- CERES key concept or product web pages would be explained in a few bullets with expandable pages and hyper-links for more information, instead of the DQS approach which overwhelmed the user
- Every page designed to help the user quickly decide the product for their application, user realizes there are multiple approaches to parameters

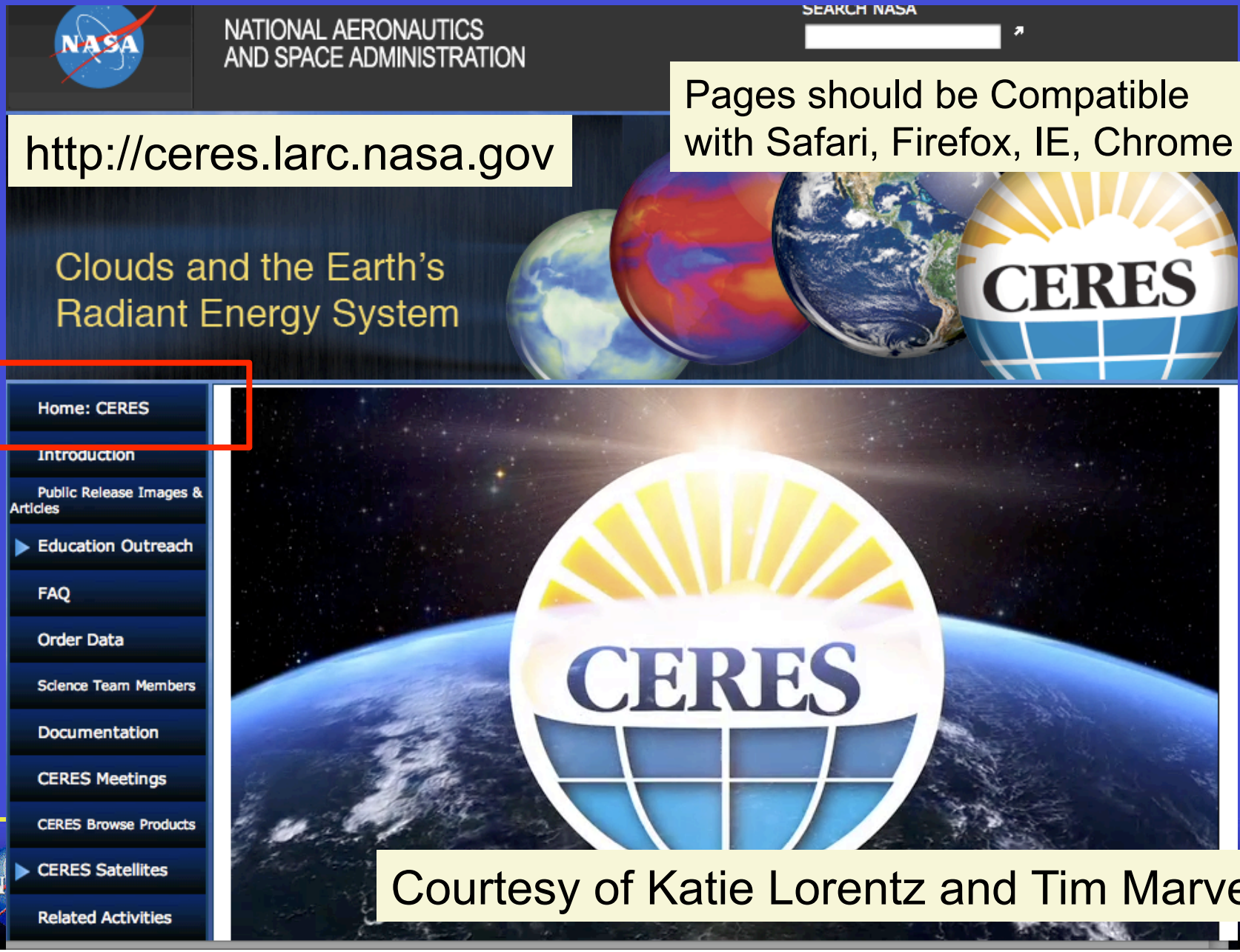
D. Doelling

NASA LaRC

K. Bedka*, J. Closs*, Z. Eitzen*, E. Kizer*, J. Norris,
D. Rutan*, P. Taylor[a], T. Wong[a]

**SSAI, [a]NASA LaRC*

CERES home page with Movie



CERES Main data order page

Product Description

Parameter, Resolution, Availability

Order Product

Level 4

Level 3

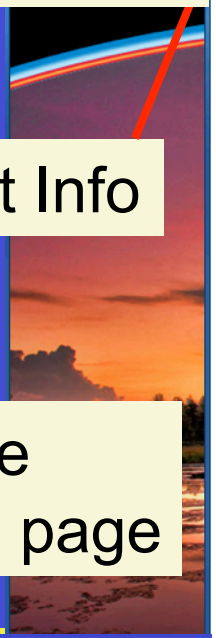
Level 2

Level 1

User feed back

Product Info

All in one ordering page



CERES Home

Order Data

Data Resolutions
Data Parameters
Data Availability

Data Products

Science Information

FAQ

A tool to help decide which product meets your application is available here.

Level 4: Consistency between TOA global net flux and ocean heat storage.

Data Product	Description	Parameter	Resolution	Availability	Order Data
EBAF	CERES TOA fluxes, energy balanced and clear-sky filled				Order Data browse & subset

Level 3: Spatial and temporally (daily, monthly, etc) averaged fluxes and cloud properties.

Data Product	Description	Parameter	Resolution	Availability	Order Data
SYN1deg	CERES observed and GEO-enhanced temporally interpolated TOA fluxes, MODIS/GEO clouds and MODIS aerosols and associated computed flux profiles CERES consistent flux and cloud properties				Order Data browse & subset
SSF1deg	CERES observed temporally interpolated TOA flux, MODIS clouds and aerosols				Order Data browse & subset
ES4/ES9	CERES observed TOA fluxes using original ERBE algorithms				Available via ASDC Ordering
ISCCP-D2like	CERES monthly cloud properties in a similar format to ISCCP	X	X	X	Available via ASDC Ordering
FLASHFlux1deg	Near real-time SSF1deg product, not officially calibrated for publication		X	X	Available via ASDC Ordering

Level 2: CERES instantaneous footprint level fluxes and cloud properties.

Data Product	Description	Parameter	Resolution	Availability	Order Data
SSF	CERES observed TOA flux, MODIS clouds and aerosols and parameterized surface fluxes		FOV*		Available via ASDC Ordering
CRS	Computed flux profiles from MODIS clouds and aerosols		FOV*		Available via ASDC Ordering
ES8	CERES observed TOA fluxes using original ERBE algorithms		FOV*		Available via ASDC Ordering
SSF-SSFM	Nadir view CERES-SSF/MODIS/MISR collocated parameters	X	FOV*		Available via ASDC Ordering
C3M	Nadir view CERES-SSF/MODIS/CALIPSO/CloudSat collocated parameters		FOV*		Available via ASDC Ordering
FLASHFlux	Near real-time SSF product, not officially calibrated for publication		FOV*		Available via ASDC Ordering

Level 1B: CERES raw engineering and instantaneous filtered radiances.

Data Product	Description	Parameter	Resolution	Availability	Order Data
BDS	CERES geo-located and calibrated TOA filtered radiances		FOV*		Available via ASDC Ordering

*FOV: Field-of-View instantaneous footprint data.

NASA

CERES

V1.1

Product Availability Page

• New Ed2.5 lite products have their own availability and are expected to be processed to Feb 2010 shortly

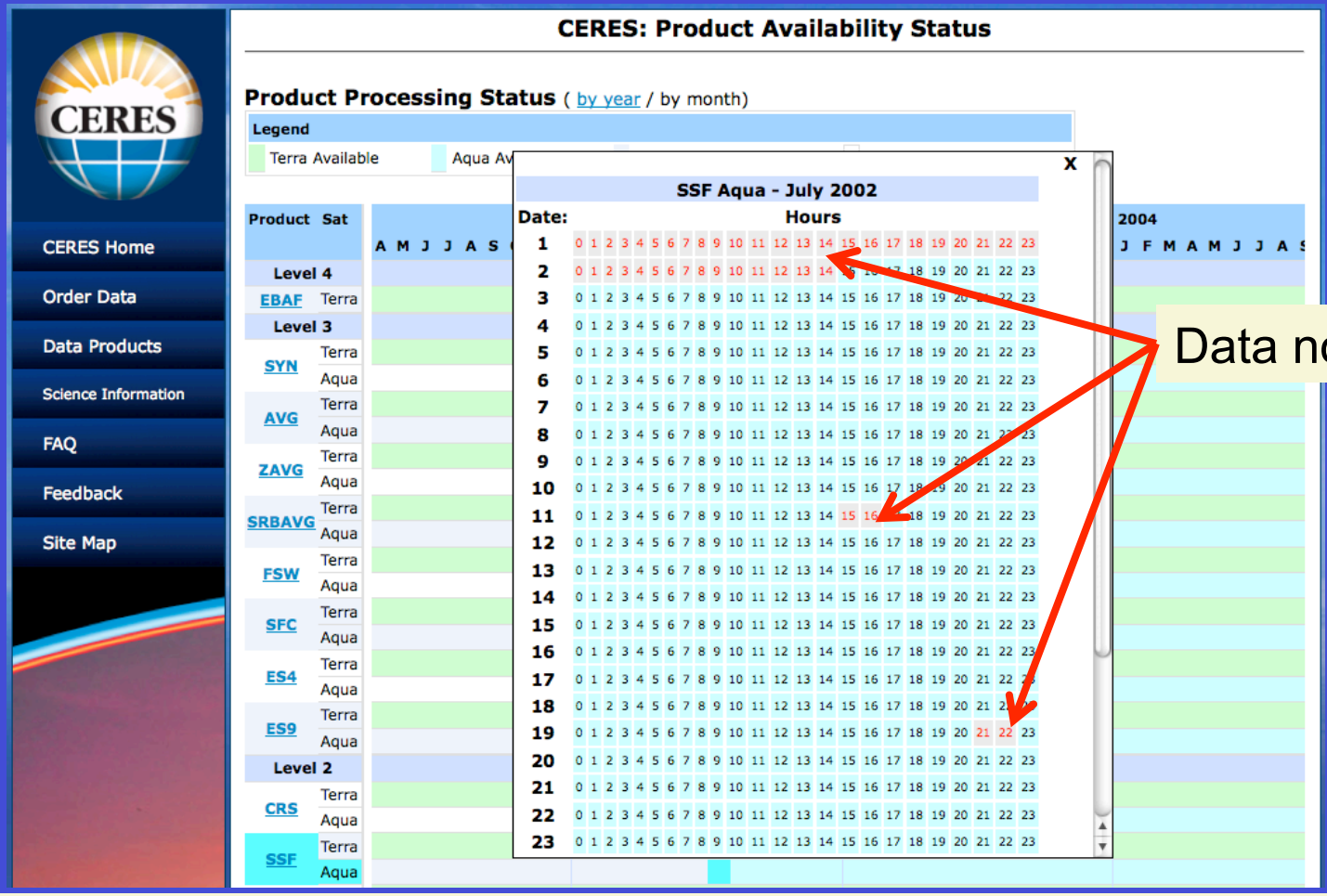
SSF1deg Product Processing Status

Product	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SSF1deg-Hour-lite Terra*	Mar								Dec		
SSF1deg-Month-lite Terra*	Mar								Dec		
SSF1deg-Hour Terra	Mar									Apr	
SSF1deg-Hour Aqua			Jul					Dec			
SSF1deg-Month Terra	Mar					Oct					
SSF1deg-Month Aqua			Jul			Oct					

• Due to the complex processing schedules, product availability is dependent on product resolution
• Availability is now dynamic

Product Availability Page

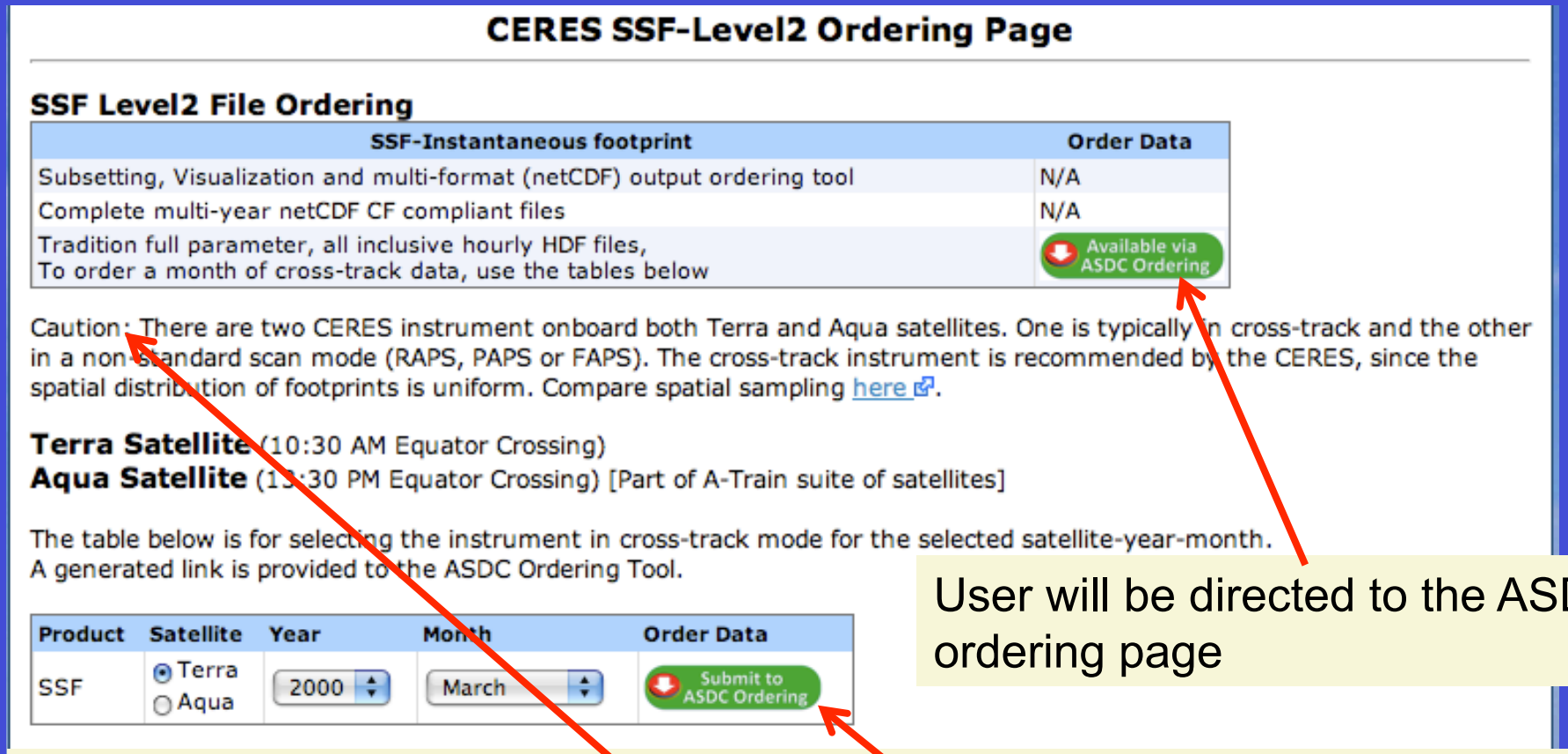
V1.1



- Availability status of products are automated via production database
- Hourly and Daily processed products expand for more detail

Individual Product Ordering Page V1.1

User always gets the latest product edition, user cautioned if new input data is used, such as GEOS-4 to 5, which triggers a new letter (ie Edition2A->Edition2B)



CERES SSF-Level2 Ordering Page

SSF Level2 File Ordering

SSF-Instantaneous footprint	Order Data
Subsetting, Visualization and multi-format (netCDF) output ordering tool	N/A
Complete multi-year netCDF CF compliant files	N/A
Tradition full parameter, all inclusive hourly HDF files, To order a month of cross-track data, use the tables below	Available via ASDC Ordering

Caution: There are two CERES instrument onboard both Terra and Aqua satellites. One is typically in cross-track and the other in a non-standard scan mode (RAPS, PAPS or FAPS). The cross-track instrument is recommended by the CERES, since the spatial distribution of footprints is uniform. Compare spatial sampling here.

Terra Satellite (10:30 AM Equator Crossing)
Aqua Satellite (13:30 PM Equator Crossing) [Part of A-Train suite of satellites]

The table below is for selecting the instrument in cross-track mode for the selected satellite-year-month.
A generated link is provided to the ASDC Ordering Tool.

Product	Satellite	Year	Month	Order Data
SSF	Terra / Aqua	2000	March	Submit to ASDC Ordering

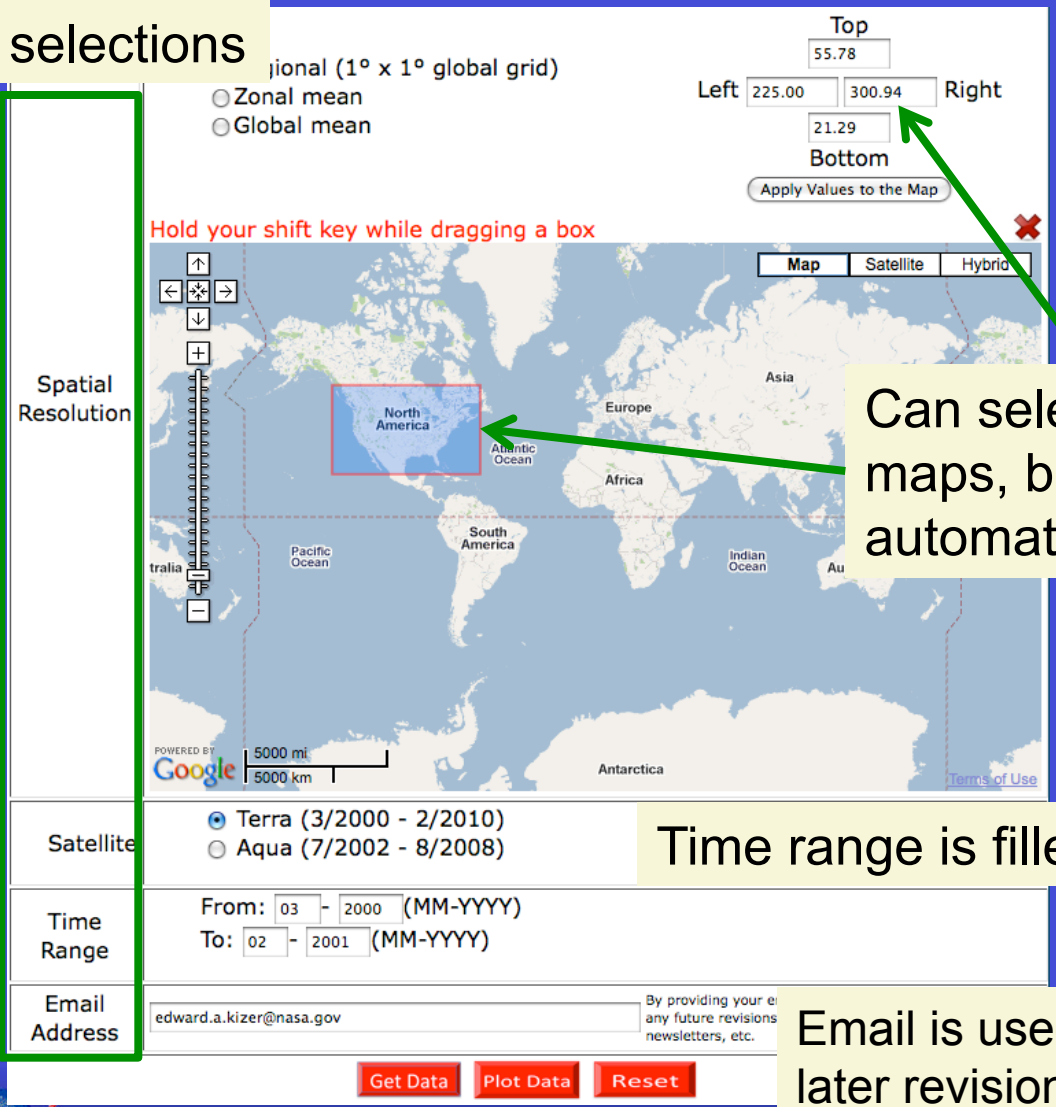
User will be directed to the ASDC ordering page

- The level 2 ordering page cautions and guides users in determining which CERES instrument was in cross-track mode and will actually select those files at the ASDC ordering page for the month selected

Product Tool Selection Page (2 of 2)

V1.1

User selections



Show expandable parameter lists

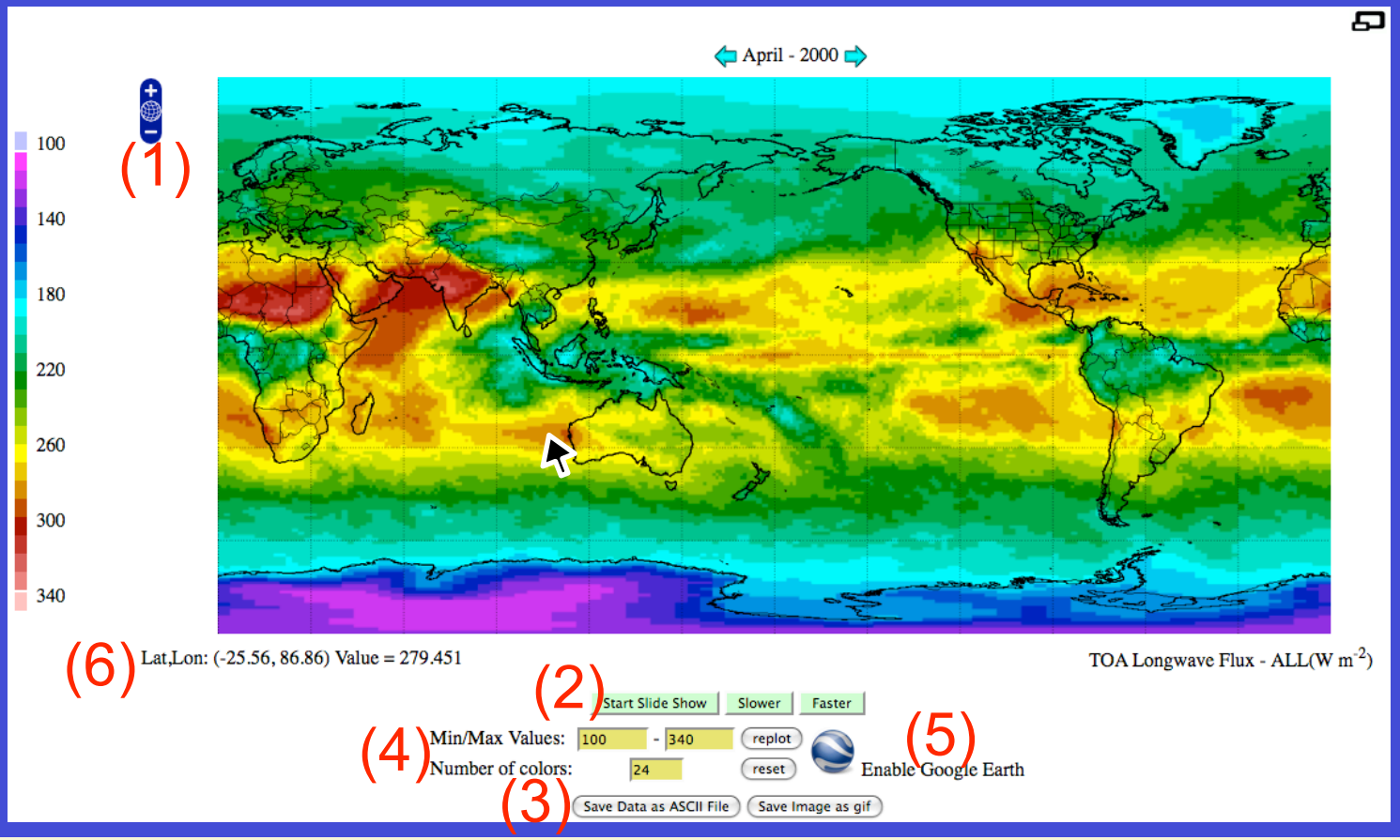
Can select regions using google maps, bounding box values are automatically captured

Time range is filled in entire time record

Email is used to inform users of later revisions or new products

Product Plotting Page

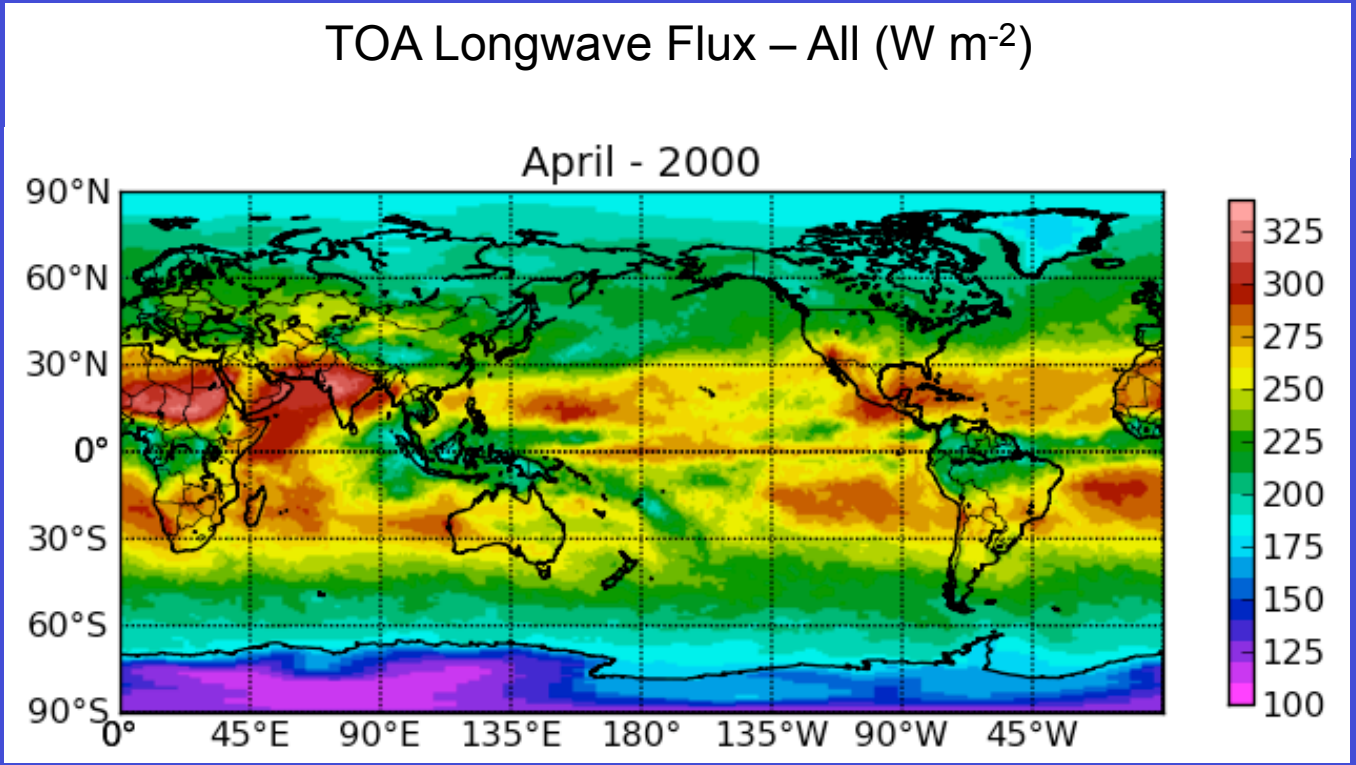
V1.1



(1) Can resize map and manually advance to the next image
(2) Can animate regional plot over many months
(3) Can save data as ascii and gif image using Python
(4) Can modify plot by adjusting colorbar min/max values and number of colors
(5) Can render image either in Google Earth or rectangle projection
(6) Can place cursor over plot and identify values

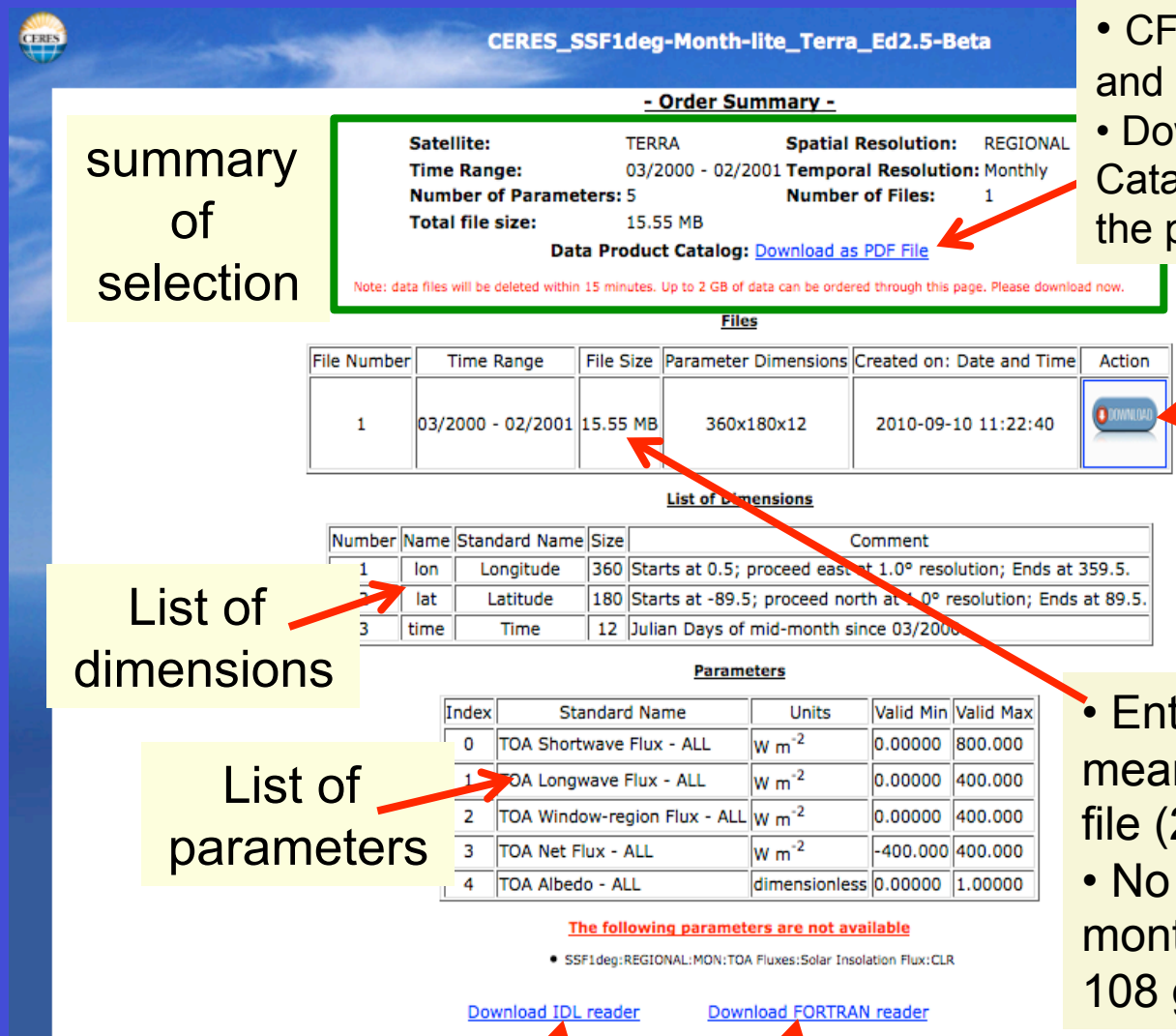
GIF Image Generation

V1.1



GIF Image generated by Python to provide users with ability to download individual images

Product Download Page



CERES_SSF1deg-Month-lite_Terra_Ed2.5-Beta

- Order Summary -

Satellite:	TERRA	**Spatial Resolution:**	REGIONAL
Time Range:	03/2000 - 02/2001	**Temporal Resolution:**	Monthly
Number of Parameters:	5	**Number of Files:**	1
Total file size:	15.55 MB		

Data Product Catalog: Download as PDF File

Note: data files will be deleted within 15 minutes. Up to 2 GB of data can be ordered through this page. Please download now.

Files

File Number	Time Range	File Size	Parameter Dimensions	Created on: Date and Time	Action
1	03/2000 - 02/2001	15.55 MB	360x180x12	2010-09-10 11:22:40	DOWNLOAD

List of dimensions

Number	Name	Standard Name	Size	Comment
1	lon	Longitude	360	Starts at 0.5; proceed east at 1.0° resolution; Ends at 359.5.
2	lat	Latitude	180	Starts at -89.5; proceed north at 1.0° resolution; Ends at 89.5.
3	time	Time	12	Julian Days of mid-month since 03/2000

Parameters

Index	Standard Name	Units	Valid Min	Valid Max
0	TOA Shortwave Flux - ALL	W m^{-2}	0.00000	800.000
1	TOA Longwave Flux - ALL	W m^{-2}	0.00000	400.000
2	TOA Window-region Flux - ALL	W m^{-2}	0.00000	400.000
3	TOA Net Flux - ALL	W m^{-2}	-400.000	400.000
4	TOA Albedo - ALL	dimensionless	0.00000	1.00000

The following parameters are not available

- SSF1deg:REGIONAL:MON:TOA Fluxes:Solar Insolation Flux:CLR

Download IDL reader Download FORTRAN reader

summary of selection

• CF compliant netCDF output, and parameter definitions
• Download Data Products Catalogues (DPC) with only the parameters selected

Download data file from web

List of dimensions

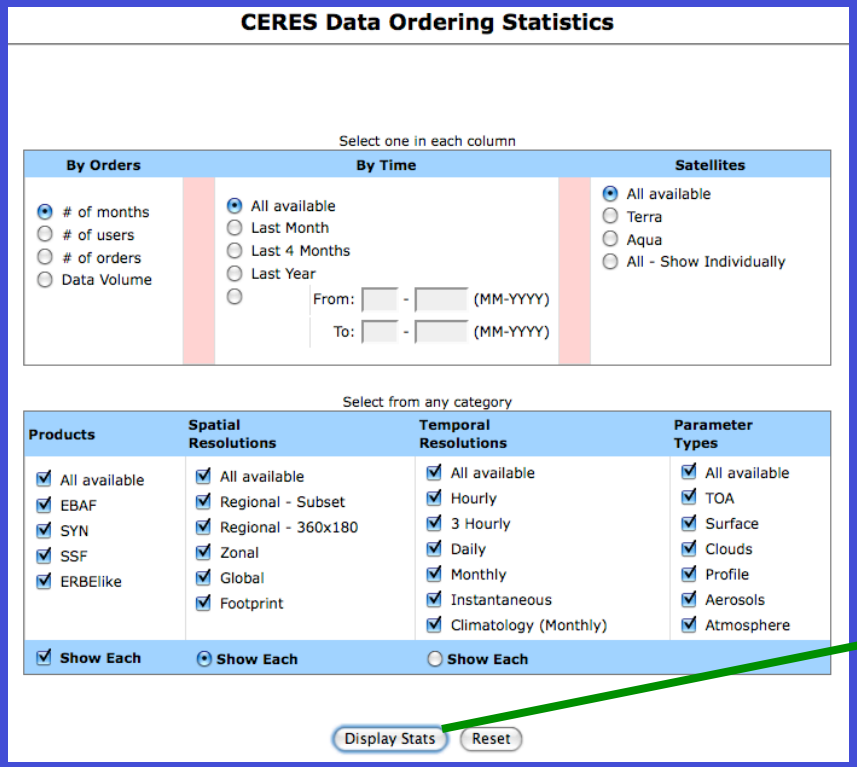
List of parameters

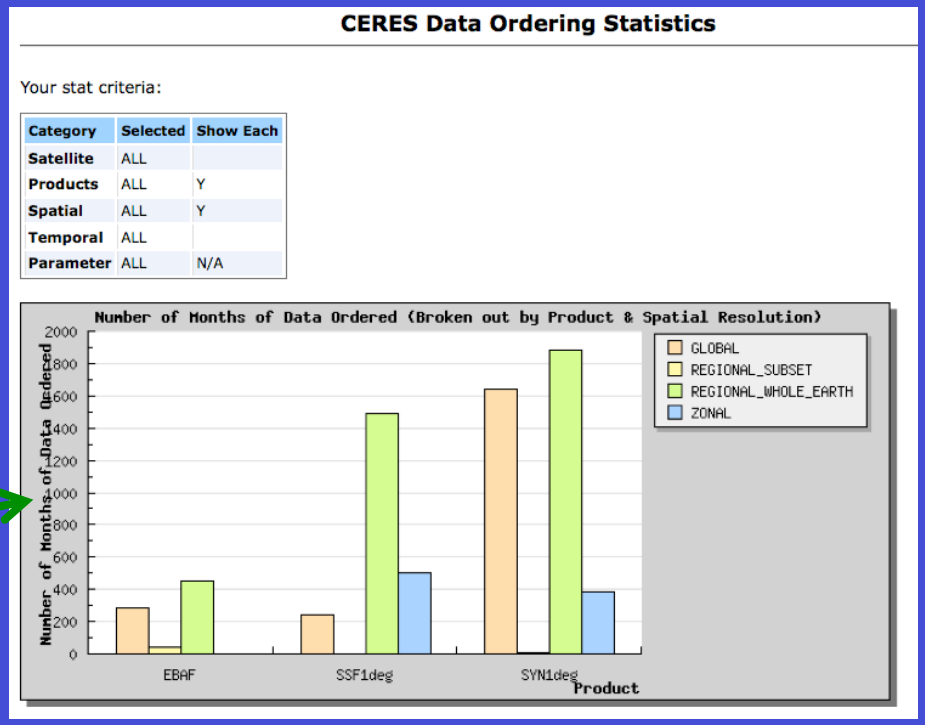
• Entire record of monthly means can be ordered as one file (2GB limit)
• No need to combine 108 monthly files x 2 GB to get 108 global means

IDL and Fortran netCDF read software

CERES Data Ordering Statistics (available to CERES STM only)

V1.1





Statistics are generated as selected

CERES Ordering Tool Highlights

- Aug 2009 – Initial web pages designed and framework developed on MAC laptops
- Jan 2010 – 3 CPU machines and 40TB hardware ordered
- Mar 2010 - Robustness review of software to ensure maximum availability and reduce single point failures
- Apr 2010 – Live demonstration of tool at CERES science team meeting
- Jun 2010 - 1 CPU machine installed @ building 1250 with Tool Version 1.0 serving SSF/SYN1deg-lite-beta data products in time for AMS radiation conference in Portland Oregon
- Aug 2010 – Newly redesigned CERES web pages go live, giving users access to tool and providing user oriented information
- Sept 2010 - 2 CPU machines and 40TB hardware being installed @ building 1268 and incorporating Edition 2.5 SSF/SYN1deg-lite and EBAF data products including daily parameters
- Oct 2010 – All hardware and software configured with Tool Version 1.1 in time for the A-train users workshop

Ordering Tool Future

- Develop FTP and shopping cart ordering approach for large datasets (daily and level 2 products)
- Follow CALIPSO/ASDC team approach for level 2 parameter subsetting and temporal and geographical search options, for example over surface sites
  - Search mechanism through meta-data
  - Subsetting software will reduce file size and provide netCDF format
- Develop level 3 parameter product comparison plotting package
- Add products as they become available as Edition3
  - Develop web pages, plotting, and subsetting for each product

TISA near term goals

- Deliveries since last April 2010
  - SFC Ed3, TSI Ed3, ISCCP-D2like geo Ed2
- Projected deliveries
  - SYN/AVG/ZAVG Ed3, GEO coefficients valid to Feb 2010
  - ISCCP-D2like merge Ed2, ISCCP-D2like flux beta
- Release lite products as Edition 2.5
  - Update all DQS, DPC, deliver to ASDC, implement on tool, fix bugs
- Edition3 improvements
  - Finalize GEO coefficients with desert, DCC, spectral corrections, consistency with Terra and Aqua MODIS
  - Quantify 1-hourly GEO over 3-hour GEO derived flux improvements
    - Normalization time reduced from 1.5 to 0.5 hours, and hourly diurnal signal
  - LW angular NB to BB and regional normalization, similar to SW
    - Currently global NB to BB coefficients and instantaneous normalization
  - LW cubic spline temporal interpolation
  - GEO based land clear-sky maps for improved GEO cloud retrievals
    - Currently using MODIS maps